This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

Usage guidelines

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

About Google Book Search

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

A 762,571

THE UNIVERSITY OF MICHIGAN
LIBRARIES
THE UNIVERSITY OF MICHIGAN
1817

THE UNIVERSITY OF MICHIGAN
LIBRARIES
THE UNIVERSITY OF MICHIGAN
1817

TRANSPORTATION LIBRARY

REPORT OF THE PROCEEDINGS

OF THE

Thirty-Eighth Annual Convention

OF THE

AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION

(*INCORPORATED*)

HELD AT

MANHATTAN BEACH, N. Y.,

June 14, 15 and 16, 1905.

CHICAGO:
THE HENRY O. SHEPARD COMPANY
120-130 SHERMAN STREET.
1905.

Transportation
Library

OFFICERS FOR 1905-1906.

ELECTED AT CLOSE OF CONVENTION OF 1905.

PRESIDENT.

H. F. BALL, Lake Shore & Michigan Southern Railway, Cleveland, Ohio.

FIRST VICE-PRESIDENT.

J. F. DEEMS, New York Central Lines, New York City.

SECOND VICE-PRESIDENT.

WM. McINTOSH, Central Railroad of New Jersey, Jersey City, N. J.

THIRD VICE-PRESIDENT.

H. H. VAUGHAN, Canadian Pacific Railway, Montreal, Canada.

TREASURER.

ANGUS SINCLAIR, New York City.

EXECUTIVE MEMBERS.

*A. E. MANCHESTER, Chicago, Milwaukee & St. Paul Railway, West Milwaukee, Wis.
*J. F. WALSH, Chesapeake & Ohio Railway, Richmond, Va.
*F. H. CLARK, Chicago, Burlington & Quincy Railway, Chicago, Ill.
°G. W. WILDIN, Erie Railroad, Meadville, Pa.
°C. A. SELEY, Chicago, Rock Island & Pacific Railway, Chicago, Ill.
°A. E. MITCHELL, Lehigh Valley Railroad, South Bethlehem, Pa.

SECRETARY.

JOS. W. TAYLOR.

* Term expires June, 1906.
° Term expires June, 1907.

Transportation
Library

COMMITTEES SELECTED FOR THE 1906 CONVENTION.

1.— Shrinkage Allowance for Tires:

To take into account the whole question of design of wheel centers, including:

1. Parted or solid rim and width of same.
2. Section of spoke as well as section of rim.
3. Securing of tires to large wheel centers.

F. J. COLE, Chairman.
J. E. MUHLFELD.
A. S. VOGT.
W. A. NETTLETON.

2.— Flexible Stay Bolts:

To continue investigations already undertaken.

R. N. DURBOROW, Chairman.
F. M. WHYTE.
C. E. FULLER.
O. H. REYNOLDS.

3.— Locomotive Tests of Pennsylvania Railroad at St. Louis Exposition:

Continued to complete the work:

F. H. CLARKE, Chairman.
H. H. VAUGHAN.
O. H. REYNOLDS.

4.— Water Softening for Locomotive Use:

To make further investigations along the line already undertaken and to consider, in addition:

"The advisability of using a mechanical or other system in

connection with a locomotive for the purpose of overcoming the bad effects from the use of undesirable feed-water."

J. A. CARNEY, Chairman.
L. H. TURNER.
F. N. RISTEEN.
R. QUAYLE.
C. E. FULLER.
J. F. DUNN.
J. G. NEUFFER.

5.— Locomotive Front Ends:

Continued to complete its investigations.

H. H. VAUGHAN, Chairman.
F. H. CLARK.
R. QUAYLE.
A. W. GIBBS.
PROF. W. F. M. GOSS.
G. M. BASFORD.

6.— Mechanical Stokers:

This committee was made a standing committee and instructed to look into the matter of stokers and report to the convention the progress being made from year to year.

WM. GARSTANG, Chairman.
J. F. WALSH.
D. F. CRAWFORD.

7.— Classification of Locomotive Repairs:

What can be done to establish a uniform method of classifying repairs on locomotives in railroad repair shops in order that reliable comparisons can be made as to the efficiency of various shops on any one system or possibly between the shops on various systems or roads?

H. H. VAUGHAN, Chairman.
D. VAN ALSTYNE.
A. E. MITCHELL.
R. QUAYLE.

8.— Engine-house Running Repair Work on Locomotives:

What is considered the best practice for doing this work, handling reports, etc., made by firemen, engineers, road foremen of engines and inspectors, and with what machine tools and hand tools should a roundhouse be equipped to get the best results?

H. T. BENTLEY, Chairman.
P. MAHER.
F. T. HYNDMAN.

9.— Locomotive Lubrication:

General consideration of the subject: (1) With reference to high steam pressures and superheated steam; (2) How far may we economize in lubrication, both internal and external; (3) The consideration of standard fittings for lubricators; (4) The consideration of sight-feed lubricators versus pumps for internal lubrication.

E. D. BRONNER, Chairman.
R. F. KILPATRICK.
C. KYLE.
R. D. SMITH.

10.— The Use of Cast Iron in Cylinders:

To consider specifications covering cast iron to be used in cylinders, cylinder bushings, cylinder heads, steam chests, valve bushings and packing rings.

G. R. HENDERSON, Chairman.
E. D. NELSON.
M. H. WICKHORST.

11.— Electricity on Steam Railroads:

The committee to consider and present to the Association the relative advantages of the different systems of electric traction now in use as applied to interurban and suburban lines; also, as far as possible, the relative cost of operating such lines by elec-

tricity and steam. The committee was also instructed to include in its investigations the different systems of gasoline, gasoline-electric and steam motor cars.

C. A. SELEY, Chairman.
W. R. McKEEN, JR.
L. R. POMEROY.
CLEMENT F. STREET.
F. J. COLE.

12.— Subjects:

To suggest topics for noon-hour discussion at the 1906 convention; also, to suggest subjects for committee work and individual papers at the 1907 convention.

R. D. SMITH, Chairman.
C. H. QUEREAU.
G. W. WILDIN.

CONSTITUTION AND BY-LAWS.

ARTICLE I.

NAME.

The name of this Association shall be the "American Railway Master Mechanics' Association."

ARTICLE II.

OBJECTS OF ASSOCIATION.

The objects of this Association shall be the advancement of knowledge concerning the principles, construction, repair and service of the rolling stock of railroads, by discussions in common, the exchange of information, and investigations and reports of the experience of its members; and to provide an organization through which the members may agree upon such joint action as may be required to give the greatest efficiency to the equipment of railroads which is intrusted to their care.

ARTICLE III.

MEMBERSHIP.

SECTION 1. The following persons may become active members of the Association on being recommended by two members in good standing, signing an application for membership and agreement to conform to the requirements of the Constitution and By-Laws, or authorizing the Secretary to sign the Constitution for them:

(1) Those above the rank of general foreman, having charge of the design, construction or repair of railway rolling stock.

(2) General foremen, if their names are presented by their superior officers.

(3) Two representatives from each locomotive and car building works.

(4) One representative member may be appointed by any railroad company to represent its interests in the Association. Such appointment shall be in writing and shall emanate from the President, General Manager or General Superintendent. Such member shall have all the privileges of an active member, including one vote on all questions, and, in addition thereto, shall, on all measures pertaining to the determination of what tests shall be conducted by the Association or the expenditure of money for conducting same, have one additional vote for each full one hundred engines which are in actual operation or in process of purchase by the road or system which he represents. Such membership shall continue until notice is given the Association of his withdrawal or the appointment of his successor.

SEC. 2. Civil and mechanical engineers, or other persons having such

a knowledge of science or practical experience in matters pertaining to the construction of rolling stock as would be of special value to the Association or railroad companies, may become associate members on being recommended by three active members. The name of such candidate shall then be referred to a committee, to be appointed by the President, which shall investigate the fitness of the candidate, and report to the Executive Committee of the Association at the next annual meeting. If the report be unanimous in favor of the candidate the name shall be submitted to letter ballot, and five dissenting votes shall reject. The number of associate members shall not exceed twenty, and they shall be entitled to all the privileges of active members, excepting that of voting.

SEC. 3. (1) All members of the Association, excepting as hereafter provided, shall be subject to the payment of such annual dues as it may be necessary to assess for the purpose of defraying the expenses of the Association, provided that no assessment shall exceed $5 a year.

(2) A representative member shall pay in addition to his personal dues as above, an amount for each additional vote to which he is entitled, as shall be determined each year by the Executive Committee, prorated upon the cost of conducting such tests as may be determined upon at each convention, provided that no such assessment shall exceed $5 per vote per year.

Such dues shall be payable when the amount thereof is announced by the President, at each annual meeting. Any member who shall be two years in arrears for annual dues, shall be notified of the fact, and if the arrears are not paid within three months after such notification, his name shall be taken from the roll and he be duly notified of the same by the Secretary.

SEC. 4. Any person who has been or may be duly qualified as a member of this Association will remain such until his resignation is voluntarily tendered, or he becomes disqualified by the terms of the Constitution. Members whose names have been dropped for non-payment of dues may be restored to membership by the unanimous consent of the Executive Committee on the payment of all back dues.

SEC. 5. Members of the Association, active or associate, who have been in good standing for not less than five years, and who through age or other cause cease to be actively engaged in the mechanical department of railway service, may, upon the unanimous vote of the members present at the annual meeting, be elected honorary members. The nominations must be made by the Executive Committee. The dues of the honorary members shall be remitted, and they shall have all the privileges of active members except that of voting.

SEC. 6. Any member who, during the meetings of the Association, shall be guilty of dishonorable conduct which is disgraceful to a railroad officer and a member of the Association, or shall refuse to obey the chairman when called to order, may be expelled by a two-thirds affirmative vote at any regular meeting of the Association held within one year from the date of the offense.

ARTICLE IV.

OFFICERS.

SECTION 1. The officers of the Association shall be a President, a First Vice-President, a Second Vice-President, a Third Vice-President, a Treasurer, a Secretary, and six Executive members, the six Executive members with the President, Vice-Presidents and Treasurer shall constitute the Executive Committee, and they, with the exception of the Secretary, shall constitute the Executive Committee of the Association.

ARTICLE V.

DUTIES OF OFFICERS.

SECTION 1. It shall be the duty of the President to preside at all the meetings of the Association, appoint all committees — designating the chairman — except as hereinafter provided, and approve all bills against the Association for payment by the Treasurer.

SEC. 2. It shall be the duty of the Vice-Presidents, according to rank, to perform the duties of the President in his absence from the meetings of the Association.

SEC. 3. In case of the absence of both President and Vice-Presidents, the members present shall elect a President *pro tempore*.

SEC. 4. It shall be the duty of the Secretary to keep a full and correct record of all transactions at the meetings of the Association; to keep a record of the names and places of residence of all members, and the name of the railway they each represent; to certify to the persons who are eligible as candidates for the Association's scholarships at the Stevens Institute of Technology; to receive and keep an account of all money paid to the Association and deliver the same to the Treasurer, taking his receipt for the amount; to receive from the Treasurer all paid bills, giving him a receipted statement of the same.

SEC. 5. It shall be the duty of the Treasurer to receive all money from the Secretary belonging to the Association; to receive all bills and pay the same, after having approval of the President; to deliver all bills paid to the Secretary at the close of each meeting, taking a receipted statement of the same and to keep an accurate book account of all transactions pertaining to his office.

ARTICLE VI.

EXECUTIVE COMMITTEE.

SECTION 1. The Executive Committee shall exercise a general supervision over the interests and affairs of the Association, recommend the amount of the annual assessment, to call, to prepare for, and to conduct general conventions, and to make all necessary purchases, expenditures and contracts required to conduct the current business of the Association, but shall have no power to make the Association liable for any debt to an

amount beyond that which at the time of contracting the same shall be in the Treasurer's hands in cash, but not subject to prior liabilities. All expenditures for special purposes shall only be made by appropriations acted upon by the Association at a regular meeting.

SEC. 2. The Executive Committee shall receive, examine and approve before public reading, all communications, papers and reports on all mechanical and scientific matters; they shall decide what portion of the reports, papers and drawings shall be submitted to each convention and what portion shall be printed in the annual report.

SEC. 3. Five members of the Executive Committee shall constitute a quorum for the transaction of business.

SEC. 4. The Executive Committee shall form with a committee of the Master Car Builders' Association a Joint Committee to decide on the place of meeting for the annual convention.

ARTICLE VII.

ASSOCIATION SCHOLARSHIPS.

It shall be the duty of the Secretary to issue a circular annually intimating the date and place when and where candidates may be examined for the scholarships of the Association in the Stevens Institute of Technology, Hoboken, New Jersey.

Acceptable candidates for the scholarship shall be, first, sons of members or of deceased members of the Association. If there is not a sufficient number of such applicants for the June examination, then applications will be received from other railroad employes or the sons of other railroad employes for the fall examination. The Secretary shall issue a proper circular in this case as before. In extending the privilege outside of the families of members, preference shall be given to employes or the sons of employes, or the sons of deceased employes of the mechanical departments.

Candidates for these scholarships shall apply to the Secretary of this Association, and if found eligible shall be given a certificate to that effect for presentation to the school authorities. This will entitle the candidate to attend the preliminary examination. If more than one candidate passes the preliminary examination, the applicant passing the highest examination shall be entitled to the scholarship, the school authorities settling the question.

The successful candidate shall be required to take the course of mechanical engineering.

ARTICLE VIII.

ELECTION OF OFFICERS.

SECTION 1. The officers of the Association, except the Secretary as hereinafter provided, shall be elected by ballot separately without nomination at the regular meeting of the Association, held in June of each year. A majority of all votes cast shall be necessary to an election, and elections

shall not be postponed. The President, Vice-Presidents and Treasurer shall hold office for one year, and Executive members for two years, or until successors are chosen, provided, however, that three Executive members shall be elected for one year at the time of the adoption of this amendment. Three Executive members shall be elected each year thereafter.

SEC. 2. Two tellers shall be appointed by the President to conduct the election and report the results.

SEC. 3. A Secretary from among the members of the Association shall be appointed by a majority of the Executive Committee at its first meeting after the annual election, or as soon thereafter as the votes of a majority of the members of the Executive Committee can be secured for a candidate. The term of office of the Secretary thus appointed, unless terminated sooner, shall cease at the first meeting, after the next annual election succeeding his appointment, of the Executive Committee organized for the transaction of business. Two-thirds of the members of the Executive Committee shall have power to remove the Secretary at any time. His compensation, if any, shall be fixed for the time that he holds office by vote of the majority of the Executive Committee. He shall also act as Secretary of the Executive Committee.

ARTICLE IX.

AUDITING COMMITTEE.

SECTION 1. At the first session of the annual meeting an Auditing Committee, consisting of three members not officers of the Association, to be nominated by any member who does not hold office, shall be elected in the same way as officers are voted for. This Auditing Committee shall examine the accounts and vouchers of the Treasurer and certify whether they have been found correct or not. After the performance of this duty they shall be discharged by the acceptance of their report by the Association.

COMMITTEE ON SUBJECTS FOR INVESTIGATION AND DISCUSSION.

SEC. 2. At each annual meeting the President shall appoint a commitee whose duty it shall be to report at the next annual meeting subjects for investigation and discussion, and if the subjects are approved by the Association the President, as hereinafter provided, shall appoint committees to report on them. It shall also be the duty of the committee to receive from members questions for discussion during the time set apart for that purpose. This committee shall determine whether such questions are suitable ones for discussion, and if so, they shall so report them to the Association.

COMMITTEES ON INVESTIGATION.

SEC. 3. When the Committee on Subjects has reported, and the Association approved of subjects for investigation, the President shall appoint individuals or special committees to investigate and report on them, and may authorize and appoint a *special* committee to investigate and report

on any subject which a majority of the members present may approve; or individual papers may be presented to the Association after approval by the Executive Committee. Papers and reports shall be presented by abstracts, which shall not occupy more than ten minutes in the reading unless otherwise ordered by the Association.

RECOMMENDATIONS OF STANDARDS.

SEC. 4. Any proposition recommending the adoption of standard construction or practice shall be in writing and be accompanied by drawings, if the latter are necessary for a clear understanding of the subject. Such proposition shall then be submitted to the Association for discussion, after which a vote shall be taken to decide whether the proposition shall be submitted for decision by letter ballot to all the members entitled to vote. If decided in the affirmative, the Secretary, within three months from the time the vote of the Association is taken on such measure, shall send by mail to each member a blank ballot, and a copy of the proposed recommendation, with a report, to be approved by the Executive Committee, of the discussion thereon; such ballot to be filled up, signed and remailed to the Secretary, who will count all the ballots received within thirty days from the date they were sent to the members, and he shall then announce the vote in such manner as the Executive Committee may prescribe. Any recommendation securing two-thirds of the votes cast shall be adopted by the Association.

SEC. 5. All reports, resolutions and recommendations involving the use, or proposed use, by railroad companies, of any device or process which forms the subject matter of any existing patent, shall first be submitted to the Executive Committee, and shall be submitted to the Association only by the Executive Committee.

ARTICLE X.

AMENDMENTS.

SECTION 1. The Constitution may be amended at any regular meeting by a two-thirds vote of the members present, provided that written notice of the proposed amendments has been given at a previous meeting at least six months before.

BY-LAWS.

TIME OF MEETING.

I. The regular meeting of the Association shall be held annually in June of each year.

HOURS OF SESSION.

II. The regular hours of session shall be from 9:30 o'clock A.M. to 1:30 o'clock P.M.

PLACE OF MEETING.

III. The time and place for holding the Annual Convention shall be selected by a Joint Committee composed of the President, three Vice-Presidents and Treasurer of this Association and a corresponding committee from the Master Car Builders' Association. This Joint Committee shall meet within six months after the convention and decide upon the time and place of meeting.

QUORUM.

IV. At any regular meeting of the Association, fifteen or more members entitled to vote shall constitute a quorum.

ORDER OF BUSINESS.

V. The business of the meetings of this Association shall, unless otherwise ordered by a vote, proceed in the following order:

1. Opening prayer.
2. Address by the President.
3. Acting on the minutes of the last meeting.
4. Reports of Secretary and Treasurer.
5. Assessment and announcement of annual dues.
6. Election of Auditing Committee.
7. Unfinished business.
8. New business.
9. Reports of committees.

10. Reading of papers and discussion of questions propounded by members.
11. Routine and miscellaneous business.
12. Election of officers.
13. Adjournment.

QUESTIONS FOR DISCUSSION, SPECIAL ORDER OF.

VI. Unless otherwise ordered, the discussion of questions proposed by members shall be the special order from 12 o'clock M. to 1 P.M. of each day of the annual meeting.

DECISIONS.

VII. The votes of a majority of the members shall be required to decide any question, motion or resolution which shall come before the Association, unless otherwise provided.

DISCUSSIONS.

VIII. No patentees or their agents shall be admitted in the meetings of the Association for the purpose of advocating the claims of any patent or patentee, unless by unanimous consent.

IX. No member shall speak more than twice in the discussion of any question until all the other members who want to speak, and have not been heard, have spoken, and no member shall have the floor more than five minutes at a time unless otherwise ordered.

NAMES AND ADDRESSES OF MEMBERS.

Active members are shown in Roman letters; representative members in italics.

ACTIVE MEMBERS.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1905	Adams, A. B		Chicago & North-Western	Huron, S. D.
1903	Adams, A. C.		Chicago, Rock Island & Pacific.	Trenton, Mo.
1896	Adams, T. E.		St. Louis Southwestern	Pine Bluff, Ark.
1888	Addis, J. W.		Texas & Pacific.	Marshall, Tex.
1895	Aiken, C. L.		Boston & Maine.	Springfield, Mass.
1887	Aldcorn, Thos.			95 Liberty st., New York City.
1902	Aldana, H. Lopez		Central Northern	Tucuman, Arg. Rep., S. A.
1903	Alexander, K. P			410 No. Central Ave., Oklahoma, O. T.
1892	Allen, G. S.		Philadelpha & Reading	Tamaqua, Pa.
1904	Allport, Wm.		Copper Range R. R.	Houghton, Mich.
1895	Amann, W. E.			520 Rialto Bldg., San Francisco, Cal.
1903	Anthony, F. S.			148 W. Douglas st., Reading, Pa.
1892	Antz, Oscar		Lake Shore & Mich. Southern	Elkhart, Ind.
1900	Appleyard, W. P.		Pullman Co	Chicago, Ill.
1887	*Arp, W. C.*	211	*Vandalia.*	*Terre Haute, Ind.*
1905	Arthur, C. G.		Southern.	Columbia, S. C.
1903	Ashton, Harry.			401 Delaware ave., Toronto, Ont., Can.
1901	Ashworth, Jas		Louisville & Nashville	Birmingham, Ala.
1905	Asselin, George		Northern Ry. of France.	Paris, France.
1890	Atkinson, R.		Philadelphia & Reading.	Reading, Pa.
1896	Atterbury, W. W.		Pennsylvania.	Philadelphia, Pa.
1887	Augustus, W.		Chicago, Burlington & Quincy	Centerville, Iowa.
1886	Austin, W. L.		Baldwin Loco. Works.	Philadelphia, Pa.
1903	Ayers, H. B		American Loco. Co.	Allegheny, Pa.
1896	Babcock, C. M.		Texas & Pacific.	Gouldsboro, La.
1898	Baker, C. F.		Boston Elevated.	Boston, Mass.
1902	Baker, P. G.		Panama	24 State st., New York. Colon (Aspinwall).
1905	Balderston, J. W.		Colo. & Wyoming	Sunrise, Wyo.
1894	Balkam, S. T.			Calle Teatro, No. 17, Monterey, N. L., Mexico.
1901	*Ball, H. F.*	710	*Lake Shore & Mich. Southern*	*Cleveland, Ohio.*
1905	Barclay, F. B.		Illinois Central.	Memphis, Tenn.
1894	Barnes, Chas. H.			27 Cypress place, Brookline, Mass.
1904	Barnes, F. P.		Santa Fe Route.	Raton, N. M.
1888	Barnes, J. B.		Wabash	Springfield, Ill.
1890	Barnum, M. K.		Chicago, Burlington & Quincy	Chicago, Ill.
1895	*Bartlett, Henry.*	1060	*Boston & Maine.*	*Boston, Mass.*
1904	Barton, T. F.		Illinois Central.	Burnside, Ill.
1899	Bates, F. L.			2171 Howard st., Sacramento, Cal.
1905	Bather, Fred		Mexican International	Torreon, Mex.
1903	Bayley, J. J.		Southern.	Lawrenceville, Va.
1889	Bean, S. L.		A. T. & S. F.	Los Angeles, Cal.
1892	Beattie, A. L		New Zealand Govt.	Wellington, N. Z.
1899	Beauclerk, T. S		Central Argentino	Rosario de Santa Fe, Arg. Rep., S. A.
1894	Beaumont, J. G.		Southern Rys. of Peru	Arequipa, Peru.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1892	Bechhold, H. G.		Cleveland Frog & Crossing Co.	Cleveland, Ohio.
1903	Benjamin, F. G		Chicago & North-Western	Clinton, Iowa.
1903	Bennett, W. J.		Chicago, Indpls. & Louisville	Lafayette, Ind.
1900	Bentley, H. T.		Chicago & North-Western	Chicago, Ill.
1902	Berry, Arthur O		Boston & Albany	Rensselaer, N. Y.
1900	Best, W. N		418 Amer. Nat'l Bank Bldg.	Los Angeles, Cal.
1892	Billingham, Jos		Baltimore & Ohio	Parkersburg, W. Va.
1903	Billingham, R. A.		Pitts. Shawmut & Northern	St. Marys, Pa.
1902	Bingaman, Chas. A.			Lima, Ohio.
1899	Bissett, J. R.		Seaboard Air Line.	Raleigh, N. C.
1901	Blake, R. P		Northern Pacific	St. Paul, Minn.
1904	Bock, M. G.		De Queen & Eastern.	De Queen, Ark.
1899	Boldridge, R. M.		Miss. Central	Hattiesburg, Miss.
1904	Boler, W. L.		Del. Lack. & Western.	Kingsland, N. J.
1904	Booth, J. S.		Caro. & Northwestern	Chester, S. C.
1904	Booth, Thos.		Pecos Valley Lines	Amarillo, Tex.
1897	Bowles, C. K.		Farmville & Powhattan.	Chester, Va.
1895	Bradeen, J. O.		N. Y. Cent. & Hudson River.	E. Buffalo, N. Y.
1888	Bradley, W. F		Ann Arbor	Toledo, Ohio.
1904	Brady, T. F		Mapini	Mapini, Durango, Mex.
1894	Branch, Geo. E		292 Prospect place,	Brooklyn, N. Y.
1896	Brangs, P. H.		11 Broadway,	New York City.
1900	Brassell, J. K.		Cal. Northwestern.	Tiburon, Cal.
1904	Braun, C. A.		Mo. Pacific.	Osawatomie, Kan.
1902	Brazier, F. W.		N. Y. Cent. & Hudson River.	New York City.
1892	Brehm, W. H.		Mo. Kan. & Tex	Parsons, Kan.
1904	Breneman, H. N		Chgo. Mil. & St. Paul	W. Milwaukee, Wis.
1897	Briggs, D. D.		Louisville & Nashville	Anniston, Ala.
1879	Briggs, R. H.		St. Louis & San Francisco	Memphis, Tenn.
1898	*Bronner, E. D*	479	*Michigan Central.*	*Detroit, Mich.*
1887	Brooke, Geo. D.		Panama Canal Commission	Ancon, Canal Zone.
1892	Brown, David		Del. Lack. & Western.	Scranton, Pa.
1905	Brown, H. B		Erie.	Cleveland, Ohio.
1896	Brown, M. D.		Mo. Kan. & Texas.	New Franklin, Mo.
1891	Brown, W. A.		Kanawha & Michigan.	Middleport, Ohio.
1904	Brown, T. A.		Louisiana & Arkansas	Stamps, Ark.
1895	Browne, T. R.		Corrington Air Brake Co.	Matteawan, N. Y.
1882	Brownell, F. G.			Muncie st., Muncie, Ind.
1897	Bruce, Geo. A		Great Northern.	St. Paul, Minn.
1890	Bruck, Henry T.		Cumb. & Penna.	Mt. Savage, Md.
1882	Bryan, H. S.		Duluth & Iron Range.	Two Harbors, Minn.
1900	Buchanan, A., Jr.		Central Vermont.	St. Albans, Vt.
1902	Buchanan, Jas.		25 Thames st.,	New York City.
1887	Buchanan, Wm.		26 Fairfield ave.,	So. Norwalk, Conn.
1905	Burgis, E. W		N.O., Ft. Jackson & Grand Isle,	Algiers, La.
1905	Burkheimer, H. W.		Southern.	Charleston, S. C.
1893	Bush, S. P		Buckeye Steel Castings Co.	Columbus, Ohio.
1903	Bushmeyer, C. J.			Enid, O. T.
1893	*Butcher, Geo. W.*	59	*San Antonio & A. Pass*	*San Antonio, Tex.*
1904	Cameron, J. E.		Atlantic & Birmingham.	Waycross, Ga.
1903	Campbell, A. A.		Kansas City Southern	Shreveport, La.
1896	Cannon, T. E.		Great Northern.	Melrose, Minn.
1905	Cardell, J		Canadian Pacific.	Calgary, Alberta, Can.
1902	Carvacristi, V. Z		Fitz-Hugh Luther Co.	Chicago, Ill.
1904	Cargo, B. B		Lake Terminal.	Lorain, Ohio.
1900	Carney, J. A.		Chicago, Burlington & Quincy	West Burlington, Iowa.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1903	Carson, F. L.		Gulf, Colo. & Santa Fe.	Cleburne, Tex.
1889	Casanave, F. D.			1710 Market st., Philadelphia, Pa.
1890	Casey, J. J.		Haskell & Barker	Michigan City, Ind.
1904	Cassidy, D. E.		Pennsylvania.	Allegheny, Pa.
1892	Chamberlin, E.			610 Grand Central Depot, New York City.
1903	Chambers, C. E.		Central R. R. of N. J	Jersey City, N. J.
1893	Chambers, Jno. S.		Atlantic Coast Line.	Wilmington, N. C.
1901	Chase, C. F.		Amer. Loco. Co.	Manchester, N. H.
1896	Chase, F. A.		Chicago, Burlington & Quincy	St. Joseph, Mo.
1904	*Chester, W. E.*	257	*Central of Georgia.*	*Savannah, Ga.*
1905	Chidley, Joseph.		Lake Shore & Mich. Southern.	Elkhart, Ind.
1893	Childs, H. A.			Rutherford, N. J.
1898	Christopher, J		Toronto, Hamilton & Buffalo	Hamilton, Ontario, Can.
1899	Christie, W. K.		Pere Marquette.	Saginaw, Mich.
1902	Churchward, G. J		Great Western.	Swindon, England.
1905	Clark, David		Arizona & New Mexico.	Clifton, Ariz.
1899	*Clark, F. H.*	1346	*Chgo. Burlington & Quincy*	*Chicago, Ill.*
1886	Clark, Isaac W.			Fayetteville, N. C.
1903	Clark, J. H.		Staten Island R. T	Clifton, S. I., New York.
1897	Clarke, Owen.		Texas & Pacific.	Marshall, Texas.
1903	Clarkson, W. S.		Northern Pacific	Livingston, Mont.
1901	Clay, S. B			1220 N. 6th st., Ft. Smith, Ark.
1893	Cleaver, F. C		Rutland	Rutland, Vt.
1877	Clifford, J. G.			10th and Kentucky sts., Louisville, Ky.
1887	Cloud, John W			82 York Road, King's Cross, London, Eng.
1903	Cockfield, William.		Mexican	Orizaba, Mexico.
1896	Cole, F. J		Amer. Loco. Co.	111 Broadway, New York City.
1904	Cole, T. J		Erie.	Meadville, Pa.
1905	Collin, George		Northern Ry. of France.	Paris, France.
1890	*Conolly, J. J.*	93	*Dul. So. Shore & Atlantic*	*Marquette, Mich.*
1879	Cook, John S		Georgia.	Augusta, Ga.
1904	Cooper, F. R.		Lehigh Valley	Buffalo, N. Y.
1902	Cota, A. J.		Chicago, Burlington & Quincy	Chicago, Ill.
1904	Coutant, M. R.		Ulster & Delaware	Rondout, N. Y.
1905	Coyle, Thomas.		Lehigh Valley	Weatherly, Pa.
1900	Crawford, D. F.		Pennsylvania Lines.	Pittsburgh, Pa.
1885	Cromwell, A. J.			1411 Hollins st., Baltimore, Md.
1904	Cromwell, O. C.		Baltimore & Ohio	Baltimore, Md.
1902	Cross, C. W.		Lake Shore & Mich. Southern	Elkhart, Ind.
1902	Cross, J. W.		Great Western Ry.	Swindon, England.
1893	*Cross, W.*	504	*Canadian Pacific.*	*Winnipeg, Man., Can.*
1899	Cumback, R. O			Plainfield, N. J.
1900	Curley, M. S.		Gulf & Ship Island	Gulfport, Miss.
1903	Curry, H. M.		Northern Pacific	St. Paul, Minn.
1903	Curtis, Theo. H.		Louisville & Nashville	Louisville, Ky.
1872	Cushing, G. W.			Evanston, Ill.
1904	Cutler, T. J.		Northern Pacific	Missoula, Mont.
1890	Davies, J. M.			56 Broad st., Plattsburgh, N. Y.
1899	Davis, Chas. H.			25 Broad st., New York City.
1892	Davis, Ed. E		Buffalo, Rochester & Pittsburg	Dubois, Pa.
1899	Davis, M. R		Portland & Rumford Falls.	Rumford Falls, Me.
1900	Davisson, F. E.		San Pedro, Los Angeles & Salt Lake	Los Angeles, Cal.
1897	Dawson, E		El Paso & North Eastern.	Alamogordo, N. M.
1903	Dawson, L. L.		Illinois Central.	McComb, Miss.
1896	Deeble, Wm. R		Tasmania Govt	Launceston, Tasmania.
1891	*Deems, J. F.*	2881	*N. Y. Central & Hudson River*	*New York City.*

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1905	Deeter, D. H		Philadelphia & Reading.	Reading, Pa.
1896	De Gress, C.		Mex. Nat. Construc. Co	Colima, Mex.
1897	Delaney, C. A.		Amer. Loco. Co.	Scranton, Pa.
1895	Delaney, H.		14 Stuyvesant	Place, Staten Island, N. Y.
1905	Delaney, S. J.		N. Y. C. & H. R. R. R.	New York City.
1899	Delano, F. A		Wabash	Chicago, Ill.
1900	Demarest, T. W.		Pennsylvania Lines	Ft. Wayne, Ind.
1905	Desmond, D. G.		Morgantown & Kingwood	Morgantown, W. Va.
1903	Deverell, A. C.		Great Northern.	St. Paul, Minn.
1905	Dewey, J. J.		Erie.	Galion, Ohio.
1896	Dickerson, S. K.		Lake Shore & Mich. Southern.	Collinwood, Ohio.
1887	Dickson, G. L.		Amer. Loco. Co.	Scranton, Pa.
1902	Dickson, Geo		Chgo. Cincinnati & Louisville	Peru, Ind.
1905	Dickson, John		Great Northern.	Grand Forks, N. D.
1900	Dillon, S. J.		Pennsylvania.	South Amboy, N. J.
1905	Dinan, Arthur		Atch. Topeka & Santa Fe	Newton, Kan.
1894	Dixon, W. F.			Podolsk, Moscow, Govt., Russia.
1897	Doebler, C. H.		Wabash	Springfield, Ill.
1905	Dolan, J. P.		St. Louis & No. Arkansas	Eureka Springs, Ark.
1898	Dolan, S. M		St. L. Iron Mtn. & Southern	Baring Cross, Ark.
1904	Dooley, W. H.		Cin. New Orleans & Tex. Pac	Chattanooga, Tenn.
1903	Doonan, W. F		Great Northern.	Whitefish, Mont.
1893	Dow, Jas. M.			Kenton, Ohio.
1899	Downing, T. M.			Mobile, Ala.
1904	Driscoll, J. L		Alabama Great Southern.	Birmingham, Ala.
1893	Drury, Michael J.		Atchison, Topeka & Santa Fe.	Winslow, Ariz.
1904	Dunham, W. E		Chicago & North-Western.	Chicago, Ill.
1903	Dunlap, P. T		Gulf, Colorado & Santa Fe.	Temple, Tex.
1900	*Dunn, A. J.*	20	*Virginia & Southwestern*	*Bristol, Va.*
1896	*Dunn, J. F.*	190	*Oregon Short Line*	*Salt Lake City, Utah.*
1902	Dunn, M.		Pennsylvania Lines.	Columbus, Ohio.
1904	Durborow, R. N		Pennsylvania.	Altoona, Pa.
1899	Egan, J. A		Mexican Southern.	Oaxaca, Mex.
1900	Elden, Edw		N. Y. C. & H. R	W. Albany, N. Y.
1869	Elliott, Henry			East St. Louis, Ill.
1899	Ellis, H. D		Anglo-Chilian Nitrate & Ry. Co.	Tocapilla, Chili.
1893	Ellis, John J.		C. St. P. M. & O	St. Paul, Minn.
1901	Emerson, G. H.		Great Northern.	St. Paul, Minn.
1893	English, H. W			Birmingham, Ala.
1893	English, Richard.		1917 Mission st.,	San Francisco, Cal.
1881	Ennis, W. C		Delaware & Hudson Co	Oneonta, N. Y.
1905	Enright, J. F		Mobile & Ohio.	Whistler, Ala.
1898	Ettinger, R. L		Southern.	Washington, D. C.
1900	Ewing, J. J.		Chesapeake & Ohio.	Richmond, Va.
1904	Farrell, R. J.			Sparta, Ill.
1900	*Feeley, T. M.*	88	*Iowa Central*	*Marshalltown, Iowa.*
1885	Ferguson, G. A		Boston & Albany R. R.	South Station, Boston, Mass.
1905	Ferguson, L. B.		Vicksburg, Shreveport & Pac	Monroe, La.
1904	Ferguson, T. G.		Cordova & Rosario.	Rosario, Arg. Rep., S. A.
1904	Fetner, W. H.		Central of Georgia	Macon, Ga.
1903	Fildes, J. H		Lehigh Valley	E. Buffalo, N. Y.
1901	Fildes, Thos.		Long Island.	Richmond Hill, L. I., N. Y.
1905	Fitzgerald, W. T.		Wisconsin & Michigan	Peshtigo, Wis.
1892	Fitzmorris, Jas.		Chicago Junction.	Union Stock Yards, Chicago, Ill.
1903	Fleischer, J. F		Chicago & North-Western.	Sioux City, Iowa.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1903	Flory, B. P.		Central of New Jersey	Jersey City, N. J.
1901	*Fogg, J. W.*	39	*Chicago Ter. Transfer*	*E. Chicago, Ind.*
1896	*Foque, T. A*	155	*M. St. Paul & S. Ste. M.*	*Minneapolis, Minn.*
1905	Ford, Daniel W.		Pacific Coast	San Luis Obispo, Cal.
1905	Forster, John.		St. Louis & San Francisco	Kansas City, Mo.
1900	Forsyth, A		Chicago, Burlington & Quincy	Aurora, Ill.
1888	Forsyth, Wm.		M. E. *The Railway Age.*	Chicago, Ill.
1904	Foster, W. T.		Tennessee Copper Co.'s Ry	Copperhill, Tenn.
1877	Fowle, I. W			Riverside, Cal.
1891	French, R. E.		Southern Pacific	Oakland, Cal.
1898	Frey, N.		Chicago, Burlington & Quincy	La Crosse, Wis.
1904	Fries, A. J.		Boston & Albany	Allston, Mass.
1903	Fryburg, F. M		Great Northern	Havre, Mont.
1890	*Fuller, C. E*	234	*Chicago & Alton*	*Bloomington, Ill.*
1872	Fuller, Wm.			213 Kennard st., Cleveland, Ohio.
1897	Gaines, F. F.		Philadelphia & Reading.	Reading, Pa.
1904	Gairns, A. H.		Colorado & Southern	Cheyenne, Wyo.
1891	Galbraith, R. M.			Pine Bluff, Ark.
1901	Gallagher, G. A		Ill. So.	Sparta, Ill.
1904	Galloway, W. S.		Baltimore & Ohio	Grafton, W. Va.
1904	Gannon, J. B		Central New England.	Hartford, Conn.
1887	Garstang, Wm.		C. C. C. & St. L.	Indianapolis, Ind.
1900	Gaskins, W. B.		St. Louis & San Francisco	Cape Girardeau, Mo.
1903	Gauthier, Jesse		Copper Range	Houghton, Mich.
1886	Gentry, T. W.		American Loco. Co.	Richmond, Va.
1905	George, Wm. E.		Western Australian Rys.	Perth, Australia.
1899	Gibb, T. M		Crystal River.	Redstone, Colo.
1888	Gibbs, A. W.		Pennsylvania.	Altoona, Pa.
1890	Gibbs, George			10 Bridge st., New York.
1902	Gibson, J. A.		Cleveland, Cin. Chic. & St. Louis,	Urbana, Ill.
1904	Gilbert, E. B		Bessemer & Lake Erie	Greenville, Pa.
1905	Gilbert, F. M		N. Y. C. & H. R. R. R.	G.C.Station, New York City.
1896	Gill, Jno		Chgo. Indianapolis & Louisville.	Lafayette, Ind.
1905	Gillett, L. D.		Norfolk & Western.	Bluefield, W. Va.
1891	Gillis, H. A.		American Loco. Co.	Richmond, Va.
1905	Gilman, G. H.		Northern Pacific	St. Paul, Minn.
1883	Gilmore, W. L.			Elkhart, Ind.
1893	Gilmour, George		N. Y. Telephone Co.,	15 Dey st., New York.
1890	Givin, F. A			797 No. 38th st., Philadelphia, Pa.
1891	Glass, John C.		Pennsylvania.	Verona, Pa.
1905	Goodale, R. J.		Illinois Central.	Centralia, Ill.
1904	Goodman, J. E.		Northern Pacific	Duluth, Minn.
1905	Goodrich, Max.		New York & Ottawa.	Ottawa, Ont., Can.
1880	Gordon, H. D.			71 John st., New York.
1903	Gossett, H. O.		Supt. G. M. Dilley & Son.	Palestine, Texas.
1900	Gould, J. E.		Chgo. Rock Island & Pacific	Goodland, Kan.
1904	Gould, J. R.		Chesapeake & Ohio.	Richmond, Va.
1899	Gould, R.		Buenos Ayres Gt. Southern	Buenos Ayres, Arg. Rep., S. A.
1892	Graham, Charles		Philadelphia & Reading.	Reading, Pa.
1894	Graham, J. A.			Wyoming, Ohio.
1903	Graham, S. C.		Chicago & North-Western	Lake City, Iowa.
1903	Grandy, W. S.		Atch. Topeka & Santa Fe	Newton, Kan.
1894	Grant, A. S.		Missouri Pac	De Soto, Mo.
1889	Greatsinger, J. L.		Brooklyn Rapid Transit.	Brooklyn, N. Y.
1897	*Greaven, Luis.*	41	*Tehuantepec National*	*Rincon, Mex.*
1905	Green, H.		So. Balto. Steel Car & Fdy. Co	Baltimore, Md.
1895	Green, Wilbur		San Antonio & Aransas Pass.	Yoakum, Tex.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1905	Greenwood, B. E.		Seaboard Air Line Ry	Portsmouth, Va.
1885	Griffith, Fred B.			797 Elmwood ave., Buffalo, N. Y.
1893	Gross, R. J.		American Loco. Co.	25 Broad st., New York.
1896	Groves, J. R.		Denver & Rio Grande.	Denver, Colo.
1900	Gurry, Geo.		Locomotive & Machine Co.	Montreal, Can.
1893	Hainen, J		Southern.	Greensboro, N. C.
1898	*Hair, John*	194	*Balto. & Ohio S.-W*	*Cincinnati, Ohio.*
1904	Hall, Chas. S		Boston & Maine.	Springfield, Mass.
1904	Hall, Grant.		Canadian Pacific.	Montreal, Can.
1902	*Hammett, P. M*	167	*Maine Central*	*Portland, Me.*
1891	Hancock, Geo. A.		St. Louis & San Francisco.	Springfield, Mo.
1893	Hancock, Wm. S.			3654 Olive st., St. Louis, Mo.
1893	Hardie, Jas.			Hardie & Co., Valparaiso, Chili
1902	Harris, J. D		Westinghouse Air Brake Co.	Wilmerding, Pa.
1898	Harrison, F. J		Buffalo, Rochester & Pittsburg.	Du Bois, Pa.
1896	Harrison, Jno.		San Paulo.	San Paulo, Brazil, S. A.
1904	Harrison, W. L		Chgo. Rock Island & Pacific	Cedar Rapids, Iowa.
1903	Hartigan, B		Rutland	Rutland, Vt.
1901	Haselton, G. H.		N. Y. C. & H. R.	W. Albany, N. Y.
1889	Haskell, B			Franklin, Pa.
1888	Hassman, Wm.		Peoria & Pekin Union	Peoria, Ill.
1905	Hatz, G. K.		Chicago & Alton	Bloomington, Ill.
1900	Hawkins, B. H.		Gold Car Heating & Light Co.	New York City.
1903	Hawkins, R. D.		Great Northern.	Minot, N. D.
1895	Hawksworth, D.		Chicago, Burlington & Quincy.	Plattsmouth, Neb.
1899	Hawthorne, J.			Susquehanna, Pa.
1898	Hayden, J. C.			Tallapoosa, Ga.
1903	Hayes, W. C.		Erie.	Jersey City, N. J.
1905	Haynen, W. J.		St. L. Iron Mtn. & Southern	Desoto, Mo.
1896	Hayward, H. S.		Pennsylvania	Jersey City, N. J.
1891	Hedley, F.		Interborough R. T. Ry. Co	New York City.
1887	Heintzleman, T. W.		Southern Pacific	Sacramento, Cal.
1892	Henderson, G. R.			20 W. 34th st., New York.
1892	Herr, Edwin M.			Edgewood Park, Pa.
1903	Herr, H. T		Denver & Rio Grande.	Denver, Colo.
1895	Hibbard, H. Wade		Cornell University.	Ithaca, N. Y.
1903	Hickey, F. P.		Seaboard Air Line.	Raleigh, N. C
1904	Hickey, Maurice		Northern Pacific	Spokane, Wash.
1901	Hickey, P. J.		C. C. C. & St. L	Mattoon, Ill.
1890	Higgins, S.		N. Y. New Haven & Hartford.	New Haven, Conn.
1901	Hildreth, F. F.		Vandalia.	Terre Haute, Ind.
1901	Hilferty, C. D.			27 University Place, Schenectady, N. Y
1896	Hill, Rufus.		Pennsylvania.	Pavonia, N. J.
1904	Hill, W. H.		Cornwall.	Lebanon, Pa.
1902	Hillman, C. R.		San Paulo.	San Paulo, Brazil, S. A.
1902	Hobson, W. P		Ches. & Ohio	Lexington, Ky.
1899	Hoffman, R. F.			609 Mulberry st., Williamsport, Pa.
1901	Hogan, C. H.		N. Y. C. & H. R.	Depew, N. Y.
1892	Holland, W. D.			Empire, Canal Zone, Panama.
1901	Holtz, D.		Western Maryland	Union Bridge, Md.
1890	Homer, John C.		Detroit, Toledo & Ironton.	Springfield, Ohio.
1896	Hopwood, Jno.		Argentine Gt. West.	Mendoza, Argentine Rep., S. A.
1896	*Horrigan, Jno.*	138	*E. J. & E., C. L. S. & E. Rys.*	*Joliet, Ill.*
1892	Howard, C. H			504 Columbia Bldg., St. Louis, Mo.
1896	Howard, Jno		Boston & Albany	Boston, Mass.
1905	Howe, H. B		New South Wales Rys	Sydney, Australia.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1903	Howson, G. N		Southern	Birmingham, Ala.
1905	Hube, A. A		New Orleans & No. Western	Thornton, Ark.
1903	Hufman, W. H		Chicago & North-Western	Baraboo, Wis.
1899	Hudson, H. G			136 Van Ness ave., Cleveland, Ohio.
1904	Hudson, W. H		Southern	Birmingham, Ala.
1890	Hufsmith, F		I. & G. N	Palestine, Tex.
1905	Hume, E. S		Western Australian Govt. Rys	Freemantle, Australia.
1890	Humphrey, A. L		Westinghouse Air Brake Co.	Pittsburgh, Pa.
1904	Hunt, H. B		American Loco. Co	Schenectady, N. Y.
1905	Hunter, H. S		Philadelphia & Reading	Philadelphia, Pa.
1896	*Hyndman, F. T.*	1192	*New York, New Haven&Hartfd.*	*New Haven, Conn.*
1896	Inge, T. S		Danville & Western	Danville, Va.
1900	Irwin, J. E		Marietta,Columbus & Clevel'd.	Marietta, Ohio.
1888	Jackson, O. H		Indianapolis Union	Indianapolis, Ind.
1899	James, E. T		Lehigh Valley	Sayre, Pa.
1896	James, Geo		N. Y. C. & St. L	Sta. S, Chicago, Ill.
1900	Jennings, Thos		Boston & Maine	Keene, N. H.
1890	Jennings, Wm		Pacific Electric Ry	Los Angeles, Cal.
1896	Johnson, A. B		Baldwin Loco. Works	Philadelphia, Pa.
1902	Johnson, Ben		Mexican Central	City of Mexico.
1887	Johnson, L. R		Canadian Pacific	Montreal, Canada.
1903	Johnson, R. A		Southern Pacific	Tucson, Ariz.
1898	Johnson, R. H			4330 Washington ave., St. Louis, Mo.
1903	Johnson, W. O			627 Ry. Exchange Bldg., Chicago, Ill.
1905	Jones, C. F		Natchez, Urania & Ruston	Urania, La.
1888	Joughins, G. R		Intercolonial	Moncton, N. B., Can.
1903	Jungling, M		Tifton, Thomasville & Gulf	Kingwood, Ga.
1896	Justice, D. J			722 W. Chestnut st., Louisville,Ky.
1905	Kaderly, W. F		Southern	Alexandria, Va.
1890	Kalbaugh, I. N		W. Virginia Cent. & Pittsburg	Elkins, W. Va.
1903	*Kapp, W. F*	51	*Rich., Fred. & Potomac*	*Richmond, Va.*
1904	Kearney, Alex		Norfolk & Western	Roanoke, Va.
1892	*Keegan, Jas. E.*	92	*Grand Rapids & Indiana*	*Grand Rapids, Mich.*
1904	Kellogg, W. L		Pere Marquette	Grand Rapids, Mich.
1896	Kells, Willard		Lehigh Valley	Sayre, Pa.
1896	Kelly, Wm		Great Northern	Spokane, Wash.
1905	Kendall, H. H		St. L. Brownsville & Mexico	Kingsville, Tex.
1904	Kendig, R. B		Lake Shore & Mich. Southern	Cleveland, Ohio.
1894	Kennedy, Jas			158 Prospect st., Cambridge, Mass.
1893	Kenney, Geo. W		Rutland	Rutland, Vt.
1901	Keyworth, T. E		Cuban Central Rys., Ltd.	Sagua La Grande, Cuba.
1904	Kidd, L. M		Mex. International	Monclava, Mex.
1890	Killen, W. E			Jacksonville, Ill.
1903	Kilpatrick, J. B		Chicago, Rock Island & Pacific.	Chicago, Ill.
1900	Kilpatrick, R. F		Dela., Lack. & Western	Scranton, Pa.
1903	Kinnaird, L. S		Clev., Akron & Columbus	Mt. Vernon, Ohio.
1905	Kinney, W. H		N. Y. Ont. & Western	Carbondale, Pa.
1902	Kipp, A. R		Wisconsin Central	Fond du Lac, Wis.
1904	Kirkpatrick, Jas		Baltimore & Ohio	Cumberland, Md.
1899	Knapp, L. I			49 W. 33d st., New York City.
1902	Knight, Wm. Edw		United Railways of Havana	Havana, Cuba.
1902	Krauss, J. I		K. C. Southern	Mena, Ark.
1905	Kyle, C		Canadian Pacific	North Bay, Ont., Can.
1899	Lachlan, Wm		E. de F. Porto Alegre & New Hamburg	Porto Alegre, Rio Grande do Sul, Brazil.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1898	Lake, E. M.		Camp & Hinton Co.	Lumberton, Miss.
1894	Lang, V. B.		Morgan & Wright	Detroit, Mich.
1888	Lape, C. F.		Scully Steel & Iron Co	Chicago, Ill.
1905	Laurent, Theo		Paris & Orleans Ry.	Paris, France.
1891	Lawes, T. A			Danville, Ill.
1896	Lawrence, J. L.		Cumb. Valley.	Chambersburg, Pa.
1890	Leach, H. L.		Bangor & Aroostook.	Houlton, Me.
1903	Leach, W. B.			383 Dorchester ave., South Boston, Mass.
1892	Lee, C. W.		Southern.	Greensboro, N. C.
1904	Leeman, W. W		Chicago, Rock Island & Pacific.	Goodland, Kan.
1888	Leigh, F. J			30 Kenilworth Road, Ealing, London, W., Eng.
1890	Leonard, A. G		Union Stock Yards.	Chicago, Ill.
1876	*Lewis, W. H.*	697	*Norfolk & Western*	*Roanoke, Va.*
1904	Link, T. C.		Cananea Cons. Copper Co	Cananea, Sonora, Mex.
1896	Linstrom, Chas		Illinois Central.	Vicksburg, Miss.
1903	Litton, Francis H		Shansi Honan Ry	Chiaotso, Honan, China
1890	*Lloyd, T. S*	1287	*Chicago, Rock Island & Pacific.*	*Chicago, Ill.*
1905	Lockwood, B. D.		Clev., Cin., Chgo. & St. Louis.	Indianapolis, Ind.
1895	Lonergan, P. T.		Boston & Albany	W. Springfield, Mass.
1899	Lovell, Alfred.		Atchison, Topeka & Santa Fe.	Chicago, Ill.
1903	Lyddon, H. A.		Northern Pacific.	Gladstone, Minn.
1905	Lynn, M. J.		Buffa. Roch. & Pittsburgh.	Salamanca, N. Y.
1894	Lyon, Tracy.		Chicago Great Western	St. Paul, Minn.
1903	MacBain, D. R.		Michigan Central.	Jackson, Mich.
1887	Macbeth, Jas		N. Y. Cent. & Hudson River	East Buffalo, N. Y.
1904	MacDonald, T. D.		Des Moines, Iowa Falls & Nor.	Iowa Falls, Iowa.
1890	Macfarlane, T. W		Mobile, Jackson & Kan. City.	Mobile, Ala.
1899	Machesney, A. G.		Baldwin Loco. Works.	Philadelphia, Pa.
1904	Machin, A. M.		St. L. Iron Mtn. & Southern	Baring Cross, Ark.
1876	Mackenzie, John			60 Hawthorne ave., Cleveland, Ohio.
1892	Mackinnon, Geo. S		Canadian Pacific.	Winnipeg, Man., Canada.
1905	Magarvey, J. R		American Loco. Co.	Dunkirk, N. Y.
1896	Maher, P.		Toledo, St. Louis & Western,	Frankfort, Ind.
1896	Mahl, I. W.		Southern Pacific	San Francisco, Cal.
1904	Malthaner, W.		Delaware & Hudson.	Green Island, N. Y.
1895	Mallinson, E. P			49 Ashford st., Brooklyn, N. Y.
1894	Manchester, A. E.		C. M. & St. P.	West Milwaukee, Wis.
1902	Manchester, H. C.		Boston & Maine.	Mechanicsville, N. Y.
1893	*Manning, J. H.*	336	*Delaware & Hudson*	*Albany, N. Y.*
1905	Mannion, T. D.		Philadelphia & Reading.	Camden, N. J.
1898	Marchbanks, James.		Wellington & Manawatu	Wellington, N. Z.
1896	Marden, J. W.		Boston & Maine.	Boston, Mass.
1903	Markle, T. M			Seattle, Wash.
1890	Marshall, E. S			St. Louis, Mo.
1891	Marshall, W. H		Lake Shore & Mich. Southern	Cleveland, Ohio.
1903	May, H. C.		Clev., Cin., Chgo. & St. Louis	Louisville, Ky.
1904	Maysilles, J. H.			1515 Union st., Schenectady, N. Y.
1905	McCarthy, M. J.		Michigan Central.	St. Thomas, Ont., Can.
1891	McConnell, J. H.			1503 Arrott Bldg., Pittsburg, Pa.
1896	McCormick, A			Colo. Springs, Colo.
1892	*McCuen, J. P.*	230	*C.N.O. & T.P and A.G.S. Rys.*	*Ludlow, Ky.*
1903	McCuen, R. E.		Lexington & Eastern	Lexington, Ky.
1891	McDonough, James.		Chicago, Rock Island & Pac	Chickasha, I. T.
1905	McEldowney, W. E.		Denver, Enid & Gulf	Enid, O. T.
1893	McElvaney, C. T.		Mo., Kansas & Texas.	Denison, Tex.
1904	McGie, John.		Choctaw, Okla. & Gulf.	Shawnee, O. T.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1905	McGoff, J. H		Atch., Topeka & Santa Fe.	Ft. Madison, Iowa.
1903	McGrath, J. T		Grand Trunk	Ft. Gratiot, Mich.
1905	McHaffie, A. B		Intercolonial	Moncton, N. B., Canada.
1903	McHattie, T.		Grand Trunk	Montreal, Can.
1890	McIntosh, Wm.		Central R. R. of N. J	Jersey City, N. J.
1893	*McKee, G. S.*	219	*Mobile & Ohio*	*Mobile, Ala.*
1901	McKeen, W. R., Jr		Union Pacific	Omaha, Neb.
1896	McLean, W. J		Bell. Bay & Brit. Col	Bellingham, Wash.
1901	McLeish, W. J			Evansville, Ind.
1894	McMasters, Chas. J.		Rutland	Malone, N. Y.
1896	McNabb, T.		A. R. & C. Co.	Lethbridge, Alberta, Can.
1890	McNaughton, Jas		Amer. Loco. Co.	Schenectady, N. Y.
1905	McNulty, F. M.		Monongahela Connecting	Pittsburgh, Pa.
1905	McRae, J. A.		Boston & Albany	Boston, Mass.
1888	Medway, John			169 8th st., Troy, N. Y.
1905	Meister, C. L.		Atlantic Coast Line.	Wilmington, N. C.
1895	Mellin, C. J.		Amer. Loco. Co.	Schenectady, N. Y.
1900	Mendenhall, C. M.		American Steel Foundries	New York City.
1903	*Menzel, W. G.*	190	*Wisconsin Central.*	*Fond du Lac, Wis.*
1892	Mertsheimer, F.		K. C. Southern	Pittsburg, Kan.
1887	Michael, J. B		Southern.	Knoxville, Tenn.
1885	Millen, Thos.		Metropolitan Street Ry	106 W 51st st., New York.
1889	*Miller, E. A.*	180	*N. Y. C. & St. L.*	*Cleveland, Ohio.*
1890	Miller, Geo. A.		Florida East Coast	St. Augustine, Fla.
1903	Miller, J. B.		St. L. Southwestern of Tex	Waco, Tex.
1901	Miller, S. W.		Pennsylvania Lines.	Columbus, Ohio.
1903	Miller, W. J		St. L. Southwestern of Tex	Tyler, Tex.
1903	Milliken, James		Phila., Balto. & Wash	Wilmington, Del.
1893	Minshull, P. H.		N. Y. O. & W.	Middletown, N. Y.
1892	Minto, H. M.		Louisville & Nashville	Mobile, Ala.
1888	Minton, A. B.		Mobile & Ohio.	Jackson, Tenn.
1892	*Mitchell, A. E.*	747	*Lehigh Valley.*	*So. Bethlehem, Pa.*
1903	Moir, William.		Northern Pacific	So. Tacoma, Wash.
1898	Moler, A. L.			Peru, Ind.
1901	Monahan, J. J.		Louisville & Nashville	Paris, Tenn.
1890	Monkhouse, H.		Rome Loco. & Mach. Wks.	Rome, N. Y.
1903	Monlaverde, F.		Paulista	Santos, Brazil.
1903	Monroe, M. S.			Chicago, Ill.
1884	Montgomery, Wm.		Cent. of N. J.	Lakehurst, N. J.
1901	Morgan, J. B		Toledo & Ohio Central.	Bucyrus, Ohio.
1890	Moore, J. H		Erie.	Rochester, N. Y.
1896	Moran, Robt.		Louisville & Nashville	Nashville, Tenn.
1887	Morris, W. S.			813 W. Berry st., Ft. Wayne, Ind.
1902	Morrison, F. B.		Panama	24 State st., New York City.
1905	Morrison, J. R		Inverness Ry. & Coal Co	Inverness, C. B., Can.
1901	Muchnic, C. M.		American Loco. Co.	Dunkirk, N. Y.
1904	Mudd, G. W		Wabash.	Moberly, Mo.
1903	Mudd, H. K.			Richmond, Ind.
1899	*Muhlfeld, J. E.*	1843	*Balto. & Ohio.*	*Baltimore, Md.*
1905	Mullen, D. J.		Clev., Cin., Chgo. & St. L.	Mt. Carmel, Ill.
1904	Murphy, J. H.		Cin., New Orleans & Tex. Pac	Ludlow, Ky.
1890	Murphy, P. H.			Murphy Car Roof Co., East St. Louis, Ill.
1903	Murrian, W. S		Southern.	Alexandria, Va.
1904	Needham, E. F		Wabash.	Ft. Wayne, Ind.
1905	Nelson, E. D.		Pennsylvania	Altoona, Pa.
1894	Nettleton, W. A.		St. Louis & San Francisco.	St. Louis, Mo.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1898	Neubert, G. T.		Kansas City Belt.	Kansas City, Mo.
1892	Neuffer, John G.		Illinois Central.	Chicago, Ill.
1901	Neville, John			San Luis Potosi, Mexico.
1896	Neward, F. H.		Pontiac, Ox. & Northern.	Pontiac, Mich.
1903	Nichols, H. E.		Minn. Transfer.	St. Paul, Minn.
1904	Nicholls, J. Mayne.			Iquique, Chili, S. A.
1875	Noble, L. C.			Fisher Bldg., Chicago, Ill.
1902	Nolan, J. C.		Arkansas Southern.	Ruston, La.
1899	Nolan, J. P.		Morgan's L.& T.R.R.& S.S.Co.	Algiers, La.
1896	Norsworthy, N. W.		Norfolk & Western.	Crewe, Va.
1902	Nutt, Geo. B.			13 Victoria st., London, Eng.
1896	Nuttall, W. H		Manistee & N. Eastern.	Manistee, Mich.
1905	O'Beirne, P.		Toluca, Marquette & Northern	Toluca, Ill.
1890	O'Brien, John.		Rich. & Petersburg.	Manchester, Va.
1903	O'Hearne, J. E.		Wheeling & Lake Erie	Norwalk, Ohio.
1890	O'Herin, Wm.		Mo., Kan. & Tex.	Parsons, Kan.
1895	O'Leary, D.			Seattle, Wash.
1905	Oplinger, J. W.		Atlantic Coast Line.	Savannah, Ga.
1901	Ord, C. R.		Canadian Pacific.	McAdam Junction, N. B., Can.
1901	Parish, LeGrand		L. S. & M. S.	Cleveland, Ohio.
1900	Parker, M. B		Rockwood & Tenn. River	Rockwood, Tenn.
1905	Parks, Geo. E.		Michigan Central.	Detroit, Mich.
1901	Park, S. T.		Chicago & Eastern Illinois.	Danville, Ill.
1903	Park, P. D		Reid Newfoundland Co.'s.	Whitbourne, N. F.
1903	Passmore, H. E.		Toledo & Ohio Central.	Kenton, Ohio.
1879	Patterson, J. S.		Galena Signal-Oil Co.,	Cincinnati, Ohio.
1904	Patterson, Robt.		Rio Grande Southern.	Ridgway, Colo.
1903	Paul, W. M.		Gal., Houston & Henderson	Galveston, Tex.
1891	Paxton, Thos.		El Paso & South Western	Douglas, Ariz.
1904	Pearce, J. S.		Norfolk & Western.	Portsmouth, Ohio.
1903	Pearsall, D. M.		Atlantic Coast Line.	Florence, S. C.
1899	Pearse, H		Buenos Ayres & Rosario,	La Quinta, Rosario de Santa Fe, Arg. Rep., S. A.
1887	*Peck, Peter H.*	75	*C. & W. I. and Belt.*	*Chicago, Ill.*
1901	Pengelly, J. H		Mexican National	Salazar, Mex.
1899	Pennington, J. H.		Dela., Susq. & Schuyl.	Drifton, Pa.
1897	Peyton, H. T		Atch., Topeka & Santa Fe.	Wellington, Kan.
1897	Pflager, H. M.		Amer. Steel Foundries	St. Louis, Mo.
1900	Phillips, C.		New Orleans & Northeastern.	Meridian, Miss.
1903	Piccioli, J		Colorado & Wyoming.	Pueblo, Colo.
1905	Pierce, F. M.		Hawkinsville & Florida Sou.	Pitts, Ga.
1902	Pilcher, J. A.		Norfolk & Western.	Roanoke, Va.
1904	Pinheiro, Antonio.		Mogyana R. R.	Campinos, Brazil, S. A.
1885	Pitkin, A. J.		American Loco. Co.	25 Broad st., New York.
1901	Place, F. E.		Buda Fdy. & Machine Co.	Harvey, Ill.
1900	Plank, P. D.		Louis., Hend. & St. L.	Cloverport, Ky.
1903	Platt, J. G.		Erie.	Meadville, Pa.
1881	Player, John.			319 Franklin ave., River Forest, Ill.
1897	Pollitt, Harry.		Great Central.	Fernlea, Altricham, Cheshire, Eng.
1900	Post, W. F.		Watkins Fdy. & Mch. Co.	Hattiesburg, Miss.
1897	Potton, J.		Texas & Pacific.	Big Springs, Tex.
1905	Powell, V. U.		Illinois Central.	Mattoon, Ill.
1903	Pratt, E. W.		Chicago & North-Western.	Missouri Valley, Iowa.
1903	Prendergast, W. H		Central of Georgia.	Columbus, Ga.
1891	Prescott, C. H.		Great Northern	Great Falls, Mont.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1905	Preston, Robt		Canadian Pacific	Toronto Jct., Toronto, Can.
1900	Prince, S. F., Jr.			122 W. 49th st., New York, N.Y.
1905	Purdy, Jos. B.		Hilo.	Hilo, Hawaii.
1890	Purves, T. B., Jr		Neponset Rubber Co	Hyde Park, Mass.
1888	*Quayle, Robert*	1307	*Chicago & North-Western.*	*Chicago, Ill.*
1895	Quereau, C. H		N. Y. C. & H. R.	W. Albany, N. Y.
1890	Randolph, L. S		Virginia Polytechnic Institute	Blacksburg, Va.
1903	Records, J. W		Santa Fe Central.	Estancia, N. M.
1901	Redding, D. J.		Pitts. & Lake Erie.	McKee's Rocks, Pa.
1904	Reeves, P. H		Baltimore & Ohio	Chillicothe, Ohio.
1902	Reid, W. L.		American Loco. Co.	Schenectady, N. Y.
1883	Renshaw, W.		Illinois Central.	Chicago, Ill.
1892	Rettew, C. E		D. & H. Co.	Carbondale, Pa.
1896	Reynolds, O. H.			132 Nassau st., New York City.
1899	Rhodes, L. B.		Georgia Southern & Florida	Macon, Ga.
1905	Rice, J. H.		De Queen & Eastern.	De Queen, Ark.
1901	Richmond, W. H.		Lake Superior & Ishpeming.	Marquette, Mich.
1903	Rickard, W. W			Tucson, Ariz.
1894	Riley, George N.		McKeesport Connecting.	Pittsburg, Pa.
1899	Risteen, F. N.		Atchison, Topeka & Santa Fe	Topeka, Kan.
1902	Robb, J. M.		Chicago Great Western	Chicago, Ill.
1901	Robb, W. D.		Grand Trunk	Montreal, P. Q.
1901	Roberts, Jos.		Union Pacific.	Armstrong, Kan.
1896	Roberts, J. W.			1124 Cornell ave., Indianapolis, Ind.
1891	Roberts, Mord.		Davis Expan. Boring Tool Co.	St. Louis, Mo.
1903	Robinson, Maynard		Gulf, Colo. & Santa Fe.	Silsbee, Tex.
1896	Rogers, M. J.			1008 West 24th st., Kansas City Mo.
1903	Rogers, R. H.		N. Y., New Haven & Hartford.	Boston, Mass.
1900	Roope, Thos.		C. R. I. & P.	Topeka, Kan.
1896	Rosing, W. H. V.		Missouri Pacific.	St. Louis, Mo.
1904	Rova, Isaac		Illinois Central.	E. St. Louis, Ill.
1895	Royal, C. B.			151 Franklin ave., Oak Park, Ill.
1898	Rumney, T.		Erie.	Meadville, Pa.
1896	Rusch, Peter C.		Buffalo, Rochester & Pittsburg	Bradford, Pa.
1903	Russell, W. H.		Southern Pacific	Oakland, Cal.
1893	Ryan, E		Gal., Houston & San Antonio	San Antonio, Tex.
1891	Ryan, J. J.		Southern Pacific	Houston, Tex.
1892	Ryan, Patrick		Louisville & Nashville	Russellville, Ky.
892	Sague, J. E.		Amer. Loco. Co.	25 Broad st., New York.
887	Sample, N. W.		Baldwin Loco. Works.	Philadelphia, Pa.
396	*Sanderson, R. P. C.*	342	*Seaboard Air Line.*	*Portsmouth, Va.*
903	*Scheffer, F. H.*	234	*Nashville, Chatt. & St. Louis.*	*Nashville, Tenn.*
903	Schilling, R. P.		Dela., Lack. & Western	Utica, N. Y.
05	Schlacks, W. J.		Colorado Midland	Colorado City, Colo.
04	Schlafge, Wm.		Erie.	Jersey City, N. J.
01	Seabrook, C. H.		St. Louis Southwestern	Pine Bluff, Ark.
75	Sedgwick, E. V.			Galena Signal-Oil Co., Franklin, Pa.
00	Seidell, G. W.		Chicago, Rock Island & Pacific.	Horton, Kan.
900	Seley, C. A.		Chicago, Rock Island & Pacific.	Chicago, Ill.
903	Sheahan, J. F.		Southern.	Columbia, S. C.
899	Shepard, L. A.			32 Broadway, New York City.
903	Shepard, Samuel.		Minn., St. P.& S. Ste. Marie	Enderlin, N. D.
1905	Shields, A.		Canadian Northern.	Winnipeg, Man., Can.
1890	Shields, J. C.		Mineral Range.	Hancock, Mich.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1904	Shoemaker, H		Del., Lack. & Western.	Scranton, Pa.
1883	Sinclair, Angus			136 Broadway, New York City.
1900	Singer, Frank.		Midland Terminal.	Canon City, Colo.
1892	Sinnott, W.		Baltimore & Ohio	58th st., Philadelphia, Pa.
1889	Skinner, H. M. C.			88 Walnut st., Fall River, Mass.
1893	Slater, Frank.		Chicago & North-Western.	Escanaba, Mich.
1894	Slayton, C. E.		Algoma Cent. & Hudson Bay.	Sault Ste. Marie, Ont., Can.
1900	Slayton, F. T.		St. Joseph & Grand Island.	St. Joseph, Mo.
1889	*Small, H. J.*	1170	*Southern Pacific.*	*San Francisco, Cal.*
1903	Smith, C. B		Boston & Maine.	Boston, Mass.
1900	Smith, D. A		Boston & Maine.	E. Somerville, Mass.
1904	Smith, E. J.		Atlantic Coast Line.	High Springs, Fla.
1893	Smith, F. B			35 Hazzard st., Jamestown, N. Y.
1896	Smith, F. C.		Amer. Loco. Co.	Manchester, N. H.
1900	Smith, F. J.		B. & O. S.-W.	Washington, Ind.
1894	Smith, H. C.		Los Angeles & Redondo.	Los Angeles, Cal.
1892	Smith, John L.		Buffalo, Rochester & Pittsburg	Du Bois, Pa.
1900	Smith, L. L.			Hartwick, Otsego Co., N.Y.
1899	Smith, R. D.		Burlington & Missouri River.	Lincoln, Neb.
1905	*Smith, R. E.*	538	*Atlantic Coast Line*	*Wilmington, N. C.*
1902	Smith, Wm.		N. Y. Cent. & Hudson River.	East Buffalo, N. Y.
1869	Smith, W. T.		Chesapeake & Ohio.	Covington, Ky.
1903	Smitham, N. L.		Texas Central	Walnut Springs, Tex.
1891	Soule, R. H			Brookline, Mass.
1901	Squire, W. C.		Loco. Appliance Co.	400 Old Colony Bldg., Chicago, Ill.
1898	Stansbury, C. M.		Chi., Rock Island & Pacific	Peoria, Ill.
1874	Stevens, Geo. W			9 Allison st., Concord, N. H.
1898	Stevenson, C. E.		Mogyana	Campinos, San Paulo, Brazil, S. A.
1903	Stewart, A		Southern.	Washington, D. C.
1900	Stewart, M. D.		Chicago, Peoria & St. Louis.	Jacksonville, Ill.
1885	Stewart, O		Bangor & Aroostook.	Oldtown, Maine.
1905	Stewart, T. R.		Baltimore & Ohio	Cumberland, Md.
1890	Stillman, H.		Southern Pacific	San Francisco, Cal.
1896	Stocks, W. H.			Chicago, Ill.
1905	Struthers, Alex		Denver, Northwestern & Pac	Denver, Colo.
1890	Studer, A. L.			Denver, Colo.
1901	Sullivan, J. J		Louisville & Nashville	New Decatur, Ala.
1891	Summerskill, T. A.		Vermont Central.	St. Albans, Vt.
1892	Sumner, Eben T		Boston & Maine.	East Cambridge, Mass.
1899	Suzuki, S.		Kinshui.	Moji, Japan.
1901	Swoyer, H.		Rogers Loco. Works.	Paterson, N. J.
1899	Symington, T. H.			St. Paul Bldg., Baltimore, Md.
1892	Symons, W. E			Pittsburg, Kan.
1894	Taft Wm. H		Boston & Albany	Allston, Mass.
1883	Tandy, H		Supt. Canadian Loco. Works.	Kingston, Ont., Can.
1896	Tawse, Robt.		Ann Arbor	Owosso, Mich.
1893	Taylor, C. M.		Atchison, Topeka & Santa Fe	La Junta, Colo.
1901	Taylor, H. D		Philadelphia & Reading.	Reading, Pa.
1893	Taylor, Wm. H		N. Y., Susquehanna & Western	Stroudsburg, Pa.
1905	Taylor, W. M.		Thornton & Alexandria	Thornton, Ark.
1903	Teat, W. F.		Atlanta, Knoxville & Northern	Blue Ridge, Ga.
1905	Temple, C. H.		Canadian Pacific.	Winnipeg, Man.
1904	Terrill, C. H.		Chesapeake & Ohio.	Huntington, W. Va.
1904	Thomas, E		Andino Ry.	Rio Cuarto, Arg. Rep., S. A.
1891	Thomas, H. T.		Detroit & Mackinac	East Tawas, Mich.
1903	Thomas, P. G.		Central R. R. of N. J	Ashley, Pa.

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1892	Thomas, J. J., Jr.		Seaboard Air Line.	Savannah, Ga.
1883	Thomas, W. H.			4230 Spruce st., Philadelphia, Pa.
1901	Thomas, W. J.		Christobal Shops.	Canal Zone.
1890	Thompson, C. A.			Morris Park, Long Island, N. Y.
1903	Thompson, E. B.		Chicago & North-Western.	Winona, Minn.
1896	Thompson, Geo.		Union Pacific.	Omaha, Neb.
1902	Thompson, W. O.		N. Y. Cent. & Hudson River.	Oswego, N. Y.
1895	Thompson, W. T.			620 W. 115th st., New York, N. Y.
1902	Thornton, Chas. J.		United Rys. of Havana	Havana, Cuba.
1883	Thow, Wm.		Government.	Eveleigh, N. S. W.
1903	Tinker, J. H.		Illinois Central.	Mounds, Ill.
1903	Todd, A. B.		Southern California.	San Bernardino, Cal.
1892	Todd, Louis C		Boston & Maine.	Boston, Mass.
1898	Tollerton, W. J		Oregon Short Line	Pocatello, Idaho.
1901	Toltz, Max		Manistee & Grand Rapids	Manistee, Mich.
1893	Tonge, John.		Minneapolis & St. Louis.	Minneapolis, Minn.
1903	Torrey, F. A.		Chicago, Bur. & Quincy.	Chicago, Ill.
1896	Tracy, W. L.		Louisville & Nashville	Louisville, Ky.
1892	Traver, W. H.		Rand Drill Co.,	Monadnock Block, Chicago, Ill.
1883	Tregelles, Henry		Care Norton, Megaw & Co.,	Rio de Janeiro, Brazil.
1890	Tuggle, S. R.		Houston & Texas Central	Houston, Tex.
1903	Tuma, Frank		Erie.	Buffalo, N. Y.
1903	Turnbull, A. G.		Erie.	Meadville, Pa.
1899	Turner, A.		Lehigh Valley	South Easton, Pa.
1890	Turner, Calvin G.		Phil., Balto. & Washington.	Wilmington, Del.
1889	Turner, Chas. E.			Rochester, N. Y.
1886	Turner, J. S			24 Broad st., New York City.
1890	*Turner, L. H*	189	*Pittsburg & Lake Erie.*	*Pittsburg, Pa.*
1883	Twombly, Fred M.			18 Farquhar St., Rosindale, Mass.
1904	Uddenberg, C. E		Swedish Government	Boden, Sweden.
1889	Vail, A.		Pennsylvania.	Buffalo, N. Y.
1898	Van Alstyne, D		Northern Pacific	St. Paul, Minn.
1905	Vanaman, C. D		Florida East Coast	St. Augustine, Fla.
1904	*Van Buskirk, H.C.*	172	*Colorado & Southern.*	*Denver, Colo.*
1896	Van Cleve, J. R.		Alaska Central.	Seward, Alaska.
1904	Van Doren, G. L		Central R. R. of New Jersey.	Elizabethport, N. J.
1905	Van Ripper, D. F		Erie.	Meadville, Pa.
1891	Vauclain, Samuel M.		Baldwin Loco. Works.	Philadelphia, Pa.
1898	*Vaughan, H. H.*	550	*Canadian Pacific*	*Montreal, Can.*
1903	Vernet, C. C.		Western Ry. of Havana.	Havana, Cuba.
1896	Villasenor, Alberto			San Jose de Costa Rica, C. A.
1892	Vogt, A. S.		Pennsylvania.	Altoona, Pa.
1899	Vought, J. H.		Lehigh Valley	South Bethlehem, Pa.
1904	Waddington, John		Central Northern R. R.	S. Cristobal, Arg. Rep., S.A.
1904	Wagstaff, George.		New York Central Lines	Buffalo, N. Y.
1905	Wahlen, John.		Montpelier & Wells River	Montpelier, Vt.
1892	Waitt, A. M.			17 Battery place, New York City, N. Y.
1893	Walker, Henry E.		Buenos Aires Western	Buenos Aires, Arg. Rep., S.A.
1904	*Wallace, W. G*	58	*Duluth, Missabe & Northern*	Duluth, Minn.
1888	Wallis, Phillip		Long Island.	Richmond Hill, L. I., N. Y.
1900	*Walsh, F. O*	32	*A. & W. P. & W. Ry. of Ala.*	*Montgomery, Ala.*

JOINED.	NAME.	NO. OF LOCOS.	ROAD.	ADDRESS.
1903	Walsh, J. F.		Chesapeake & Ohio.	Richmond, Va.
1874	Walsh, Thos.		Louisville & Nashville	Howell, Ind.
1902	Walsh, W. C.		Southern Indiana	Bedford, Ind.
1896	Walton, E. A.		N. Y. Cent. & Hudson River.	Corning, N. Y.
1883	Warren, Beriah		1619 Pennsylvania ave.,	St. Louis, Mo.
1882	Warren, W. B		1619 Pennsylvania ave..	St. Louis, Mo.
1903	Waters, J. J.		Mex. International	Ciudad Porfirio Dias, Mex.
1902	Watson, Samuel		N. Y. Cent. & Hudson River.	W. Albany, N. Y.
1904	Watters, J. H.		Georgia	Augusta, Ga.
1883	Watts, Amos H.		Cincinnati Northern.	Van Wert, Ohio.
1900	Welch, C. H.		Midland Valley	Excelsior, Ark.
1903	Wellisch, Louis			693 Hague ave., St. Paul, Minn.
1880	*West, G. W.*	167	*N. Y. O. & W*	*Middletown, N. Y.*
1899	Westmark, H. O			144 N. Lake st., Aurora, Ill.
1903	Whale, George.		London & Northwestern	Crewe, England.
1903	Whetstone, John.		Norfolk & Southern	Berkley, Va.
1885	White, A. M.		American Loco. Co	Manchester, N. H.
1894	White, E. T.		Baltimore & Ohio	Mt. Clare, Baltimore, Md.
1901	White, W.			New York City.
1898	Whyte, F. M		N. Y. Cent. & Hudson River.	New York City.
1905	Wickhorst, M. H		Chgo., Burl. & Quincy	Aurora, Ill.
1899	Wiest, E. N		Man. & North-Eastern.	Manistee, Mich.
1894	Wiggin, Chas. H		Boston & Maine.	Malden, Mass.
1878	Wightman, D. A.			Warren, R. I.
1900	Wilbur, I. N.		Chgo., Burl. & Quincy	Hannibal, Mo.
1891	Wilcox, W. J		Mexican Central	Chihuahua, Mex.
1901	Wildin, G. W.		Erie.	Meadville, Pa.
1896	Williams, Alfred		Paulista	Paulista, Brazil, S. A
1905	Williams, C. R.		Buffa. & Susquehanna.	Galeton, Pa.
1891	Williams, E. A.		Erie.	New York, N. Y.
1903	Williams, F. W.			Lyndhurst, N. J.
1905	Willius, Gustav, Jr		Great Northern.	St. Paul, Minn.
1905	Wilson, Charles		Lehigh Valley	Wilkesbarre, Pa.
1887	Wilson, G. F.		Dela., Lack. & Western	New York City.
1901	Wilson, W. H.		Erie.	Susquehanna, Pa.
1900	Wirt, G.		C. C. C. & St. L	Delaware, Ohio.
1903	Woodruff, S. N		Minn., St. P. & S. Ste. Marie.	Gladstone, Mich.
1903	Worsdell, Wilson.		North-Eastern.	Gateshead-on-Tyne, Eng.
1901	Wright, R. V.		American Engineer.	285 N. 20th st., E. Orange, N. J.
1903	Yergens, W. F		Erie.	Huntington, Ind.
1896	Yohn, C. R.		H. & B. T. Mtn	Saxton, Pa.
1899	York, C. C.		B. A. & Pac. Estacion Junin,	Buenos Ayres, Arg. Rep., S. A.
1902	Young, C. B.		Chicago, Burlington & Quincy	Chicago, Ill.
1905	Young, R. R.		Atlantic Coast Line.	Waycross, Ga.
1895	Young, W. H.		Atlantic Coast Line.	Savannah, Ga.
1898	Zerbee, F. J		C. C. C. & St. L.	Bellefontaine, Ohio.

ASSOCIATE MEMBERS.

JOINED.	NAME.	ADDRESS.
1893	Baker, Geo. H	227 Monroe st., Brooklyn, N. Y.
1898	Basford, G. M	Amer. Loco. Co., 111 Broadway, New York City.
1898	Bates, E. C	Lock Box 1544, Boston, Mass.
1903	Casey, F. A	271 Franklin st., Boston, Mass.
1896	Fowler, Geo. L	53 Broadway, New York City.
1895	Goss, W. F. M	Purdue University, Lafayette, Ind.
1889	Hill, John A	80 Munn ave., E. Orange, N. J.
1904	Hodgins, George	136 Liberty st., New York City.
1899	Kneass, Strickland L	Wm. Sellers Co., Ltd., Philadelphia, Pa.
1901	Lane, F. W	*Railway Age*, Monadnock Bldg., Chicago, Ill.
1904	Lanza, Gaetano	Mass. Inst. of Technology, Boston, Mass.
1901	Player, John	American Loco. Co. Brooks Works, Dunkirk, N. Y.
1889	Pomeroy, L. R	General Electric Co., 44 Broad st., New York City.
1899	Smart, R. A	Westinghouse E. & M. Co., Pittsburgh, Pa.
1882	Smith, W. A	Manhattan Bldg., Chicago, Ill.
1899	Street, Clement F	Westinghouse E. & M. Co., Pittsburgh, Pa.
1903	Taylor, Jos. W	390 Old Colony Bldg., Chicago, Ill.

HONORARY MEMBERS.

JOINED.	NAME.	ROAD.	ADDRESS.
1885	Becker, Andrew		New Decatur, Ala.
1883	Blackwell, Chas.		Mt. Lookout, Cincinnati, O.
1870	Bushnell, R. W		Cedar Rapids, Iowa.
1879	Cooke, Allen		Danville, Ill.
1869	Coolidge, G. A		Barnard ave., Watertown, Mass.
1870	Cooper, H. L		Chesterton, Ind.
1876	Cory, Chas. H		Lima, Ohio.
1895	Coster, E. L	Residence, Irvington-on-Hudson	Broad Exchange Bldg., 25 Broad st., New York City.
1870	Divine, J. F	W. & Weldon	Wilmington, N. C.
1881	Eastman, A. G.		Sutton, Que.
1871	Forney, M. N.		501 Fifth ave., New York City.
1872	Foss, J. M.	Cent. Vermont	St. Albans, Vt.
1885	Galloway, A.	C. H. & D.	Cincinnati, Ohio.
1871	Hewitt, John		1323 So. Jefferson st., St. Louis, Mo.
1874	Jeffery, E. T.	Denver & Rio Grande	Denver, Colo.
1868	Johan, Jacob		Springfield, Ill.
1868	Kinsey, J. I	Lehigh Valley	Easton, Pa.
1873	Lewis, W. H.		Hoboken, N. J.
1878	Maglenn, Jas	Seaboard Air Line	Raleigh, N. C.

JOINED.	NAME.	ROAD.	ADDRESS.
1869	McKenna, John		2005 N. Alabama ave., Indianapolis, Ind.
1871	Miles, F. B		Bement & Miles, Philadelphia, Pa.
1885	Paxson, L. B	P. & R	Reading, Pa.
1872	Philbric, J. W		Waterville, Me.
1878	Pilsbury, Amos		Portland, Me.
1874	Place, T. W		Waterloo, Iowa.
1887	Rhodes, Godfrey W		Quebec, P. Q., Can.
1869	Richards, George		14 Auburn st., Roxbury, Mass.
1870	Robinson, W. A		Hamilton, Ont.
1869	Sellers, Morris		Western Union Bldg., Chicago, Ill.
1874	Schlacks, Henry		Denver, Colo.
1868	Shaver, D. O		Pittsburg, Pa.
1888	Sheppard, F. L	Pennsylvania	Altoona, Pa.
1891	Sheer, J. M		514 Seventh st., E. St. Louis, Ill.
1868	Sprague, H. N		Jamestown, N. Y.
1869	Setchel, J. H		Cuba, N. Y.
1875	Strode, Jas		Elmira, N. Y.
1883	Sullivan, A. W	Illinois Central	Chicago, Ill.
1869	Thompson, John		51 Lakewood Road, Newton Highlands, Mass.
1870	Towne, H. A		54 S. Third st., Minneapolis, Minn.
1868	Wells, Reuben		Paterson, N. J.

PROCEEDINGS.

WEDNESDAY'S SESSION.

Proceedings of Wednesday morning's session, June 14, 1905, of the Thirty-eighth Annual Convention of the American Railway Master Mechanics' Association, held in the ballroom of the Oriental Hotel, Manhattan Beach, New York, June 14, 15, 16, 1905.

President Peter H. Peck, Master Mechanic of the Chicago & Western Indiana Railroad Company, of Chicago, Illinois, called the meeting to order at 10 o'clock.

PRESIDENT PECK: The convention will please come to order. I would invite the presidents and vice-presidents of the Master Car Builders' Association and the Master Mechanics' Association to take seats on the platform. Mr. Johann, Mr. Waitt, Mr. Grieves, Mr. Brazier, please come forward.

Ladies and gentlemen, it has always been our custom to open our convention with prayer. I therefore take pleasure in introducing to you Rev. William T. Pray, of the Methodist Episcopal Church of Sheepshead Bay, who will open the exercises with prayer.

Dr. Pray led in prayer.

THE PRESIDENT: We expected to have the president of the borough of Brooklyn here to address us, but through some unforeseen circumstances he is not here. The President then delivered the following address of welcome:

To the members of the American Railway Master Mechanics' Association and friends:

It affords me a great pleasure to welcome you to this, our thirty-ninth annual convention, and I am delighted to see so large a number of mem-

bers and friends present on this auspicious occasion. We have departed from our usual custom of meeting in the mountains, to enjoy the pleasures of the seashore. We have held eight of our conventions in Saratoga, and some of us feel so well acquainted with the good citizens of that great summer resort, and so much at home, that were an election held during our stay there, we might wish to exercise the right of voting.

During the last two or three years, quite a feeling to change the place of meeting has sprung up; that the seashore should be selected if a place could be found where the accommodations were adequate to our requirements. Your Executive Committee appointed an able committee to investigate the merits of the different places thought desirable, and after a thorough search, this beautiful location on the shore of the Atlantic Ocean was selected, and I feel assured by the hearty reception given us that we will return to our homes well satisfied with the change.

The reports of our Secretary and Treasurer will show that the Association is growing and its affairs in good condition. For several years there has existed a feeling that a consolidation with our sister organization, the Master Car Builders' Association, should be effected. At a joint meeting of the Executive Committee of both organizations, held in New York last December, the subject was thoroughly considered; the advantages and disadvantages were carefully weighed, and it was the unanimous opinion of the members of both Executive Committees that nothing could be gained by any closer relations than now exist between the two Associations.

At the last convention, the committee which had been appointed in 1903 to assist the *American Engineer and Railroad Journal* in the tests being carried out at Purdue University, Lafayette, Indiana, to determine the proper dimensions for a standard front end, made a report of progress and outlined a series of tests which it was thought very desirable should be conducted, the tests to include experiments on a large engine having a front end not less than seventy-five inches in diameter.

At the same convention the Committee on Boiler Design presented a very valuable report, and the discussion brought out the fact that there is a great lack of reliable data, regarding the proper proportions of grate surface, length of tubes and many other features in that line, and a resolution was adopted that the Executive Committee be authorized to procure a fund of not exceeding $5,000 to be used under the direction of a special committee to conduct a series of tests and experiments concerning the values of varying proportions and dimensions of heating surface, grate surface and such other important features of boiler design, as might, in the opinion of the committee, be found desirable. When your Executive Committee met to formulate the program for this year's convention, these matters were considered, and it was thought best to endeavor to assist the Committee on Locomotive Front Ends in the work it had outlined, as a partial fulfilment of the wishes of the Association. Accordingly, the railroads of the country were asked to contribute the

fund necessary, and I am pleased to say that the response was most cheerful and liberal. We now have a fund of over $3,000 for conducting the tests during the coming year. Arrangements have been made for an engine of modern design, the testing plant at Purdue University will be available in the early fall, and I feel assured that under the watchful care of the committee on this subject, we will be furnished with data next year which will be of great value to all the railroads.

While it is believed this feature of boiler design is being well taken care of, and the results we are after will be forthcoming, we should not lose sight of the recommendations made last year by the Committee on Boiler Design, and investigations should be carried on to find out the values of the varying proportions and dimensions of heating surface, grate surface, etc.

In accordance with the action of the Association last year, whereby the Constitution was modified to provide for representative membership, the necessary steps have been taken for the appointment of such members, and already the number of representatives appointed is very gratifying. By this method of procuring funds, we will be enabled to carry to completion tests and experiments which will be of inestimable value to our members and the roads they represent. As has already been stated, your Executive Committee has only partially arranged to carry out the wishes of the Association as expressed in the resolution adopted last year on the presentation of the report of the Committee on Boiler Design.

It is my opinion that we are lacking in standards. I can see no reason why a standard design can not be made for a 17, 18, 19, 20 or 21 inch cylinder, also piston heads, packing rings, piston rods, cross heads, driving boxes, shoes and wedges, eccentrics and straps, steam chests and covers. By adopting standards for these parts, long delays could be avoided in ordering for replacements. Many of us remember the delay and trouble experienced before driving-wheel centers were adopted as standard. Since their adoption manufacturers keep a stock on hand available for immediate use and delays to repairs of engines are thus decreased. At the present time there are about 47,474 locomotives in the country. These have a grate surface of 1,342,578 square feet, or about 31 acres; the heating surface amounts to 78,686,339 square feet, or about 1,809 acres. As our grate surface increases, so does the fuel consumption. According to the Interstate Commerce Commission reports, the increases for the last eight years are as follows:

	PER CENT		PER CENT
1897	.0937	1901	.1060
1898	.0946	1902	.1078
1899	.0948	1903	.1168
1900	.0980	1904	.1204

It is well known that the larger the grate area, the greater the coal

consumption, much of which is caused by cleaning fires, drifting, delays on side tracks and at terminals.

While our motive power has steadily increased in numbers, size and power, the improvements in shops and shop tools have not kept pace with the locomotive problem, and while some progress is being made in the matter of up-to-date shops, much more yet remains to be done. In the discussion of a paper read before the Western Railway Club recently, it was stated that it was a difficult matter to overhaul a 100-ton locomotive in a 50-ton shop, and I believe the statement represents pretty clearly the average conditions that exist on our railroads to-day. The statement also was made that the value of an engine invested in tools and the small items that go to make up the full complement of shop equipment would result in greater service out of nineteen engines than the purchase of twenty engines alone.

In a paper on "Locomotives of Great Power," read before the International Railway Congress last month, Mr. Muhlfeld, General Superintendent Motive Power, Baltimore & Ohio R. R., gives a very clear and concise statement, in his concluding remarks, as to the condition of the locomotive problem of to-day. I am in hearty accord with the different statements he makes, and especially so with the idea that the elimination of individual preferences, patented devices, fads and frills which have no real value and a return to the use of a simple, practical design and construction will produce more satisfactory results.

The statement that decreased efficiency has resulted from the irregular transferring and crewing of locomotives for long runs, and that the regular assignment of locomotives should accomplish the best results, meets with my approval. My experience leads me to the opinion that the pooling of locomotives is not economical in either fuel, repairs or maintenance, especially on an ordinary sized road.

It is not my purpose to go into details as to the matters you have to consider at this convention; copies of the reports of the committees appointed last year, and the individual papers that will be read, have been distributed to the members, and I hope the discussions will be full and complete, so that we may advance in knowledge pertaining to our craft and be thereby the better fitted to discharge our various duties.

As has been the custom, our railway supply friends have placed before you for your inspection their latest and best devices, and while we are not in session, I would bespeak your attendance on their display. Each year these exhibits are becoming more and more a necessary part of our convention, and we are thus enabled to keep up to date in the improvements that are always being made in both machinery and materials.

As I stated before, it is a pleasure to greet so many members and friends, and especially so the ladies, and we wish that their stay here may be most enjoyable.

Before closing I wish to assure to our Secretary the appreciation of

the Executive Committee and myself of the hard work and valuable assistance he has rendered.

I thank you, ladies and gentlemen, for your kind attention.

We will now take a recess for five minutes to allow those who wish to retire, but we would be pleased to have you remain with us during our meetings.

The following members registered as present at this and subsequent sessions:

Adams, T. E.
Allen, G. S.
Anthony, F. S.
Antz, Oscar.
Arp, W. C.
Atkinson, R.

Baker, Geo. H.
Ball, H. F.
Barton, T. F.
Basford, G. M.
Bender, E. N.
Best, W. N.
Billingham, R. A.
Bissett, J. R.
Blewett, Scott H.
Boler, W. L.
Bradeen, J. O.
Branch, G. E.
Brangs, P. H.
Brazier, F. W.
Brown, David.
Brown, H. E.
Brown, W. A.
Bryan, H. S.
Buchanan, Jas.

Cargo, B. B.
Casey, F. A.
Chamberlain, E.
Chambers, C. E.
Chambers, J. S.
Chidley, Jos.
Chester, W. E.
Christopher, J.
Clark, F. H.
Cleaver, F. C.
Cook, Jno. S.
Cooper, F. R.
Cole, F. J.
Cole, T. J.
Conelly, J. J.
Cory, C. H.
Cota, A. J.
Coutant, M. R.
Coyle, Thos.
Cross, C. W.
Cross, W.
Cumback, R. O.
Curtis, Theo. H.
Cyphers, Wm. G.
Cushing, Geo. W.

Davisson, F. E.
Deems, J. F.
Deeter, D. H.
Delaney, C. A.
Delaney, H.
Dellert, W. H.
Depue, G. T.
Dewey, J. J.
Dickerson, S. M.
Doebler, C. H.
Dooley, W. H.
Downing, I. S.
Downing, T. M.
Dunn, A. J.
Dunn, J. F.

Ellis, J. J.
Ennis, W. C.
Enright, J. F.
Ettinger, R. L.

Feeley, T. M.
Fetner, W. H.
Fildes, J. H.
Fildes, Thos.
Flory, B. P.
Fogg, J. W.
Forney, M. N.
Forster, Jno.
Forsyth, Wm.
Fries, A. J.
Fry, L. H.
Fowler, G. L.
Fowler, W. E.
Fuller, C. E.

Gaines, F. F.
Gentry, T. W.
Gilbert, E. B.
Gilbert, F. M.
Gill, Jno.
Gilman, G. H.
Gilmore, W. L.
Goodrich, Max.
Gordon, H. D.
Goss, W. F. M.
Graham, Chas.
Greenwood, B. E.

Hainen, J.
Haines, W. S.
Hair, John
Hall, C. S.
Hall, Grant.
Harrison, F. J.
Hartigan, Bert.
Haselton, G. H.
Haskell, B.
Hayes, W. C.

Hawkins, B. H.
Hedley, Frank.
Henderson, G. R.
Hibbard, H. Wade.
Hickey, P. J.
Hill, John A.
Hill, Rufus.
Hill, W. H.
Hogan, C. H.
Holtz, David.
Howe, H. B.
Howard, C. H.
Howard, Jno.
Hufsmith, F.
Humphrey, A. L.
Hunt, H. B.
Hunter, H. S.
Hyndman, F. T.

Ingersoll, G. R.
Irwin, J. E.

Jackson, C. H.
James, E. T.
Johann, Jacob.
Johnson, L. R.

Kapp, W. F.
Keegan, J. E.
Kendig, R. B.
Kilpatrick, J. B.
Kilpatrick, R. F.
Kittredge, A. M.
Kyle, C.

Lane, F. W.
Lape, C. F.
Leach, W. B.
Lewis, W. H.
Lockwood, B. D.
Lonergan, P. T.

MacBain, D. R.
Mackenzie, Jno.
Malthaner, W.
Mallinson, E. P.
Manchester, A. E.
Manchester, H. C.
Mandeville, H.
Manning, J. H.
McCarthy, M. J.
McCuen, J. P.
McCuen, R. E.
McFeatters, F. R.
McHaffie, A. B.
McHattie, T.
McIlwain, J. D.
McIntosh, Wm.
McMaster, C. J.
McNaughton, James.
McNulty, F. M.
Mellin, C. J.
Mendenhall, C. M.
Menzel, W. G.
Miller, E. A.
Miller, G. A.
Miller, S. W.
Mitchell, A. E.
Minshull, P. H.
Moir, Wm.
Monahan, J. J.
Monkhouse, H.
Montgomery, Wm.
Morrison, T. D.
Muchnic, C. M.
Murphy, J. H.

Neubert, G. T.
Neuffer, J. G.
Noble, L. C.
Nolan, J. P.

O'Hearne, J. E.
Ord, C. R.
Owens, W. H.

Parish, Le Grand.
Park, S. T.
Parker, M. B.
Parks, G. E.
Passmore, H. E.
Patterson, G. G.
Pearsall, D. M.
Peck, P. H.
Pennington, J. H.
Pepper, H. E.
Perry, H. M.
Phillips, C.
Platt, J. G.
Pomeroy, L. R.
Pratt, E. W.
Preston, Robt.

Quereau, C. H.

Redding, D. J.
Reynolds, O. H.
Riley, G. N.
Robb, W. D.
Roberts, Mord.
Robider, W. J.
Robinson, Frank.
Rosing, W. H. V.
Rumney, T.

Scheetz, E. S.
Schilling, R. P.
Schlacks, Henry.
Schlacks, Jos.
Schlafge, Wm.
Seidell, C. W.
Seley, C. A.
Setchel, J. H.
Sinclair, Angus.
Sinnott, Wm.
Sharp, W. E.
Shepard, Louis A.
Shoemaker, H.
Smith, D. A.
Smith, F. D.
Smith, F. C.
Smith, G. W.
Smith, R. D.
Smith, W. A.
Smith, Wm.
Smith, W. T.
Squire, Willis C.
Stewart, C. J.

Stewart, M. D.
Stewart, O.
Stocks, W. H.
Street, Clement F.
Sumner, Eben T.
Swoyer, H.
Symons, W. E.

Tandy, H.
Taylor, J. W.
Taylor, W. H.
Thomas, J. G.
Thomas, W. H.
Thompson, C. A.
Thompson, Geo.
Thompson, W. O.
Thompson, W. T.
Tinker, J. H.
Todd, L. C.
Tonge, Jno.
Traver, W. H.
Tuma, Frank.
Turner, Amos.
Turner, C. E.
Turner, J. S.

Van Doren, G. L.
Vaughan, H. H.

Wagstaff, Geo.
Wahlen, Jno.
Waitt, A. M.
Wallace, W. G.
Walsh, F. O.
Walsh, J. F.
Waters, J. J.
Watson, S.
Watts, H. W.
Webster, H. A.
West, G. W.
Whetstone, Jno.
White, A. M.
White, W.
Whyte, F. M.
Wiest, E. N.
Wiggin, C. H.
Wilber, I. N.
Wildin, G. W.
Williams, E. A.
Williams, F. W.
Wilson, Chas.
Wilson, G. F.
Wilson, W. H.
Wirt, G.
Wright, R. V.

THE PRESIDENT: The convention will again come to order. The next business in order is the approving of the minutes of the last annual meeting. The minutes have been printed and distributed so there will be no necessity for reading them. If there are no objections to the minutes as printed, they will stand approved as printed. There being no objection it is so ordered.

The next order of business is the report of the Secretary. The Secretary will please read his report.

To the President and Executive Committee of the American Railway Master Mechanics' Association:

Below are appended statements showing the membership and receipts and expenditures of the Association during the year just closed:

ACTIVE MEMBERS.

Membership June, 1904		738
Transferred to honorary membership	2	
Deaths	7	
Resignations	8	
Dropped, non-payment dues	36	
Dropped, account mail returned	3	56
		682
New members during year		56
Total		738

ASSOCIATE MEMBERS.

Membership June, 1904	16
Resigned	1
	15
Elected June, 1904	2
Total	17

HONORARY MEMBERS.

Membership June, 1904	37
Deaths	1
	36
Transferred from active	2
Total	38
Total members:	
Active	738
Associate	17
Honorary	38
	793

At the convention of 1904, Messrs. Andrew Beckert and Henry Schlacks were transferred to honorary membership.

During the year the following resignations were received:

Associate member: F. W. Dean.

Active members: W. W. Lowell, William Smith, A. W. Twombly, J. J. Impett, W. L. Gilmore, G. W. Rhodes, J. N. Spragge, A. S. Erskine.

The following deaths have been recorded:

Active members: J. R. Slack, G. W. Hepburn, D. S. Cooper, C. F. Thomas, R. H. Gilmour, T. F. Rotheram, T. M. Conlon.

Honorary member: J. M. Boon.

The following thirty-nine names have been taken from the list of members because of non-payment of dues and because their addresses have been lost:

Z. T. Brantner.	A. F. Stewart.	W. Harrington.
Jno. Birse.	Calvin Skinner.	J. A. Hanglin.
Jas. Collinson.	G. W. Taylor.	Alex. Laird.
J. D. Campbell.	F. F. Tynan.	G. C. Morton.
Geo. Donahue.	G. E. Van Brunt.	C. F. Rommel.
N. Frey.	Jas. Cunningham.	J. T. Robinson.
C. B. Hutchinson.	S. R. Boardman.	L. H. Spillard.
T. J. Hatswell.	C. J. Cooper.	W. H. Tompkins.

J. H. Hansgen.	C. J. Clifford.	A. E. Tremp.
W. W. Layman.	R. J. Callendar.	T. H. Tyrrell.
G. W. Miller.	Jno. Foulk.	C. F. Ward.
H. M. Meaney.	G. W. Gage.	A. B. Withers.
E. M. Roberts.	W. W. Hodgkins.	

RECEIPTS.

The receipts and expenditures during the year ended June 1, the date of closing the books preparatory to this report, were as follows:

To dues collected from members	$3,380.00
" sale of Proceedings	1,117.99
" sale of index of Proceedings	4.49
" Ryerson scholarship	667.50
" Treasurer	500.00
Total	$5,669.98

EXPENDITURES.

Paid electros., zinc cuts, etc.	$ 125.90
" exchange	13.00
" expenses committees	120.31
" expenses convention, 1904	34.50
" express	139.61
" office expenses	70.41
" office rent	167.52
" printing	2,545.10
" reporting convention, 1904	231.10
" Ryerson scholarship	693.30
" salary, Secretary, June 15, 1904, to June 15, 1905, including clerk	1,200.00
" stamps and stamped envelopes	227.38
" surety bonds, Secretary	6.80
" telegrams	1.78
" tracings, blue-prints	12.25
" balance remitted to Treasurer	81.02
Total	$5,669.98

The bills against the Association are all paid except for printing some of the reports of committees which were printed after the books were closed.

The unpaid dues amount to $855.

A statement, showing the members in arrears and the amounts, is presented herewith for the information of the members.

A detailed statement of the dues collected from members during the year is made a part of this report.

At the convention of 1904 the Committee on Locomotive Front Ends suggested a series of tests in connection with its work. The estimated cost of this was $2,150. The tests were approved and the Executive Committee instructed to procure the funds. This your committee did by addressing a communication to the Superintendents of Motive Power of the principal roads of the country, soliciting a contribution on the basis of $10 per hundred engines owned. The response to this request was both prompt and generous, and in the report of the Committee on Locomotive Front Ends is given a list of the contributors to this fund and the amounts contributed. The funds now in the hands of the Secretary for this work are as follows:

Total contribution	$3,065.00
Interest to date	12.44
Total	$3,077.44

SCHOLARSHIPS.

The scholarships at Stevens Institute of Technology have not gone begging. As fast as a vacancy occurs there has been no lack of candidates. There will be one vacancy this year and already several candidates have applied for the necessary certificate to enter the competitive examination.

The Ryerson scholarship at Purdue University is held by Mr. Arthur B. Marsh, who continues to acquit himself with high honors. The report of the Registrar of Purdue University is as follows:

"DEAR SIR,— Mr. Arthur B. Marsh is a sophomore in the school of mechanical engineering. He is just completing, with high credit, his second year of work in the University, which has included several advance subjects. His work has been uniformly of an excellent character and his bearing and attitude have been that of a gentleman. In my judgment, his work and conduct have fully justified his appointment to the Ryerson scholarship. (Signed) A. M. KENYON,
Registrar."

At the convention of 1904, an amendment to the constitution was adopted looking to the establishment of a representative form of membership in this Association similar in character to that existing in the Master Car Builders' Association. Under the direction of the Executive Committee, a letter was addressed to the heads of the mechanical departments of the various railroads throughout the United States, Canada and Mexico, under date of May 15, 1905, calling attention to this provision of the constitution and enclosing a blank form for the appointment of such members. The following appointments have already been received:

NAME.	ROAD.	NO. OF ENGINES.
J. E. Keegan	G. R. & I. Ry	92
J. J. Conolly	D. S. S. & A. Ry	93
W. G. Wallace	D. M. & N. Ry	58
A. E. Mitchell	L. V. R. R	747
F. T. Hyndman	N. Y. N. H. & H	1,192
G. W. West	N. Y. O. & W. Ry	167
G. S. McKee	M. & O. Ry	219
P. M. Hammett	Maine Central R. R	167
T. S. Lloyd	C. R. I. & P. Ry	1,287
L. H. Turner	P. & L. E. Ry	189
J. H. Manning	D. & H. Co	336
John Horrigan	E. J. & E. Ry., C. L. S. & E. Ry	138
W. F. Kapp	R. F. & P. Ry	51
R. P. C. Sanderson	S. A. L. Ry	342
E. D. Bronner	Mich. Central R. R	479
W. E. Chester	C. of G. Ry	257
W. G. Menzel	W. C. Ry	190
F. H. Scheffer	N. C. & St. L. Ry	234
W. H. Lewis	N. & W. Ry	697
F. O. Walsh	A. & W. P. Ry	32
J. P. McCuen	C. N. O. & T. P. Ry	230
J. W. Fogg	C. T. T. Ry	39
T. M. Feeley	Ia. Cent. Ry	88
E. A. Miller	N. Y. C. & St. L. Ry	180
H. F. Ball	L. S. & M. S. Ry	710
J. F. Dunn	O. S. L. Ry	190
T. A. Foque	M. St. P. & S. S. M. Ry	155
C. E. Fuller	C. & A. Ry	234
W. E. Symons	Kan. City So. Ry	149
R. Quayle	C. & N.-W. Ry	1,307
P. H. Peck	C. & W. I. Ry. & Belt Ry	75
Louis Greaven	Natl. R. R. of Tehuantepec	41
H. J. Small	Southern Pacific Co	1,170
H. C. Van Buskirk	Colo. & Southern Ry	172
R. E. Smith	Atlantic Coast Line R. R	538
J. E. Muhlfeld	Baltimore & Ohio R. R	1,840
John Hair	Balti. & Ohio Southwestern R. R	194
F. H. Clark	Chicago, Bur. & Quincy Ry	1,346
H. H. Vaughan	Can. Pac. Ry. (East)	550
W. Cross	Can. Pac. Ry. (West)	504
G. W. Butcher	San Antonio & Aransas Pass. Ry	59
Henry Bartlett	Boston & Maine R. R	1,060
A. J. Dunn	Virginia & Southwestern Ry	20
W. C. Arp	Vandalia R. R	211
		18,029

NEW MEMBERS.

William Allport, M. M., Copper Range Railroad, Houghton, Mich.

J. W. Balderston, M. M., Colorado & Wyoming Railway, Sunrise, Wyo.

W. L. Boler, D. M. M., D. L. & W. Ry., Kingsland, N. J.

C. A. Braun, M. M., Mo. Pac. Ry., Osawatomie, Kan.

E. W. Burgis, M. M., N. O. Ft. J. & G. I. Ry., Algiers, La.

J. E. Cameron, M. M., Atlantic & Birmingham Ry., Waycross, Ga.

David Clark, M. M., A. & N. M. R. R., Clifton, Ariz.

Thomas Coyle, M. M., Lehigh Valley Railroad, Weatherly, Pa.

Oliver C. Crowmell, M. E., Balto. & Ohio Railroad, Mt. Claire, Baltimore, Md.

John J. Dewey, M. M., Erie Railroad, Galion, Ohio.

John P. Dolan, M. M., St. L. & N. A. Ry., Eureka Springs, Ark.

T. J. Ferguson, Asst. Loco. Supt., C. & S. Ry., Argentine Republic, South America.

W. T. Fitzgerald, M. M., Wis. & Mich. Ry., Peshtigo, Wis.

John Forster, D. V. M., St. L. & S. F. R. R., Kansas City, Mo.

W. S. Galloway, M. M., Balto. & Ohio R. R., Grafton, W. Va.

E. B. Gilbert, S. M. P., B. & L. E. R. R., Greenville, Pa.

L. D. Gillett, M. M., N. & W. Ry., Bluefield, W. Va.

B. E. Greenwood, G. F., S. A. L. Ry., Portsmouth, Va.

J. R. Gould, M. M., C. & O. Ry., Richmond, Va.

Charles S. Hall, M. M., B. & M. R. R., Springfield, Mass.

G. J. Hatz, M. M., C. & A. Ry., Bloomington, Ill.

W. H. Hill, M. M., Cornwall R. R., Lebanon, Pa.

A. A. Hube, M. M., L. & N. W. R. Ry., Gibbsland, La.

H. B. Hunt, Asst. M. S., Erie R. R., Meadville, Pa.

C. F. Jones, M. M., N. U. & R. Ry., Urania, La.

H. H. Kendall, S. M. P., St. L. B. & M. Ry., Kingsville, Tex.

R. B. Kendig, M. E., L. S. & M. S. Ry., Cleveland, Ohio.

L. M. Kidd, M. M., C. & P. Ry., Saltillo, Mexico.

C. Kyle, M. M., Canadian Pac. Ry., North Bay, Canada.

T. C. Link, M. M., Cananea Copper Co.'s Ry., La Cananea Sonora, Mexico.

M. J. Lynn, M. M., B. R. & P. Ry., Salamanca, N. Y.

A. M. Machin, M. M., St. L. I. M. & So. Ry., Baring Cross, Ark.

W. Malthaner, M. M., D. & H. R. R., Green Island, N. Y.

W. E. McEldowney, M. M., D. E. & G. Ry., Enid, O. T.

J. R. Morrison, M. M., Inverness Ry. & Coal Co., Inverness, C. B., Canada.

J. H. Murphy, M. M., C. N. O. & T. P. Ry., Ludlow, Ky.

P. O'Beirne, S. M., T. M. & N. Ry., Toluca, Ill.

G. E. Parks, M. E., Mich. Central R. R., Detroit, Mich.

F. M. Pierce, M. M., H. & F. S. Ry., Pitts, Ga.

R. Preston, M. M., Can. Pac. Ry., Toronto Junction, Ontario.

Joseph B. Purdy, M. M., Hilo Ry., Hilo, Hawaii.

P. H. Reeves, M. M., Balto. & Ohio R. R., Chillicothe, Ohio.
J. H. Rice, M. M., DeQueen & Eastern R. R., DeQueen, Ark.
W. J. Schlacks, S. M., Colo. Midland Ry., Colorado City, Colo.
A. Shields, M. M., Can. Nor. Ry., Winnipeg, Manitoba.
H. Shoemaker, M. M., D. L. & W. Ry., Scranton, Pa.
William Schlafge, M. M., Erie R. R., Jersey City, N. J.
Thomas R. Stewart, D. M. M., B. & O. R. R., Cumberland, Md.
A. Struthers, M. M., D. N. W. & P. Ry., Denver, Colo.
E. Thomas, S. M. P., Andino Ry., Rio Cuarto, Argentine Republic, South America.
G. L. Van Doren, Supt. Shops, C. R. R. of N. J., Elizabethport, N. J.
John Waddington, Dist. Loco. Supt., Central Northern Ry., S. Cristobal, Argentine Republic, South America.
George Waggstaff, Asst. M. M., L. S. & M. S. Ry., Collinwood, Ohio.
J. H. Watters, Asst. M. M., Georgia R. R., Augusta, Ga.
C. R. Williams, G. M. M., Buffalo & Susquehanna R. R., Galeton, Pa.
Charles Wilson, M. M., Lehigh Valley R. R., Wilkesbarre, Pa.

DETAILED STATEMENT OF DUES COLLECTED FROM MEMBERS.

1904.		
June 28	C. L. Aiken....	$ 10.00
" 27	Thos. Aldcorn .	5.00
" 28	C. S. Allen.....	5.00
" 27	W. C. Arp.....	5.00
" 29	R. Atkinson ...	10.00
" 29	G. H. Baker....	5.00
" 23	W. L. Boler....	5.00
" 28	J. O. Bradeen..	5.00
" 22	David Brown ..	5.00
" 27	T. R. Brown...	5.00
" 28	Wm. Buchanan .	5.00
" 27	C. E. Chambers.	5.00
" 27	J. Christopher ..	5.00
" 27	J. J. Conolly....	5.00
" 28	O. C. Cromwell.	5.00
" 29	W. Cross	5.00
" 25	R. O. Cumback.	5.00
July 2	M. S. Curley....	5.00
June 28	C. A. Delaney...	5.00
" 27	H. Delaney	5.00
" 27	W. H. Dooley..	5.00
July 2	Geo. Dickson ..	5.00
Carried forward		$ 120.00

Brought forward		$ 120.00
June 28	W. F. Doonan..	5.00
" 27	A. J. Fries.....	5.00
July 2	G. A. Gallagher.	5.00
June 28	J. A. Gibson....	5.00
" 27	J. Hainen	5.00
" 27	C. S. Hall.....	5.00
" 28	G. A. Hancock..	5.00
" 27	G. H. Haselton.	5.00
" 23	W. H. Hill.....	5.00
July 2	F. F. Hildreth..	5.00
June 23	J. C. Homer....	5.00
" 27	Jno. Howard ..	10.00
" 27	F. T. Hyndman.	5.00
" 28	O. H. Jackson..	5.00
July 2	R. H. Johnson..	5.00
" 2	M. Jungling ...	5.00
June 28	E. B. Gilbert....	5.00
" 27	J. B. Kilpatrick.	5.00
" 27	R. F. Kilpatrick.	5.00
July 2	C. W. Lee.....	5.00
" 2	Chas. Lindstrom	5.00
June 28	A. M. Machin..	5.00
Carried forward		$ 235.00

		Brought forward	$ 235.00
July	2	J. H. Maysilles.	5.00
June	27	R. E. McCuen..	5.00
"	28	Wm. McIntosh .	5.00
"	28	C. A. Miller....	5.00
"	27	S. W. Miller...	5.00
"	28	P. H. Minshull.	5.00
July	2	M. S. Monroe..	5.00
"	2	Wm. Montgomery	10.00
June	27	J. H. Murphy...	5.00
"	27	W. S. Murriam.	5.00
July	2	Jno. Neville ...	5.00
June	27	Thos. Paxton ..	5.00
"	27	C. Phillips	5.00
"	27	Jno. Player	5.00
"	27	O. H. Reynolds	5.00
"	27	J. J. Ryan.....	5.00
July	2	Patrick Ryan ..	5.00
June	27	L. A. Shepard..	5.00
"	23	H. Shoemaker .	5.00
July	2	D. A. Smith....	5.00
June	27	F. C. Smith.....	10.00
July	2	H. C. Smith....	5.00
June	22	O. Stewart	5.00
"	27	E. T. Sumner...	10.00
"	27	H. Swoyer	5.00
"	26	C. H. Terrell...	5.00
July	2	Geo. Thompson .	5.00
"	2	L. C. Todd.....	5.00
June	27	Jno. Tonge	5.00
"	27	G. L. VanDoren	5.00
"	27	E. A. Walton..	5.00
"	27	E. T. White....	5.00
"	27	D. A. Wightman	5.00
"	29	J. L. Driscoll...	5.00
July	6	E. S. Marshall..	5.00
"	6	W. P. Appleyard	5.00
"	6	C. A. Seley.....	5.00
"	6	W. H. Huffman.	5.00
"	6	W. H. Taylor..	5.00
"	6	Wm. Lachlan ..	5.00
"	6	E. M. Herr.....	5.00
"	6	A. Buchanan, Jr.	10.00
"	6	W. G. Wallace.	5.00
		Carried forward	$ 470.00

		Brought forward	$ 470.00
July	6	S. F. Prince, Jr.	5.00
"	6	W. L. Reid.....	5.00
"	6	C. H. Howard..	5.00
"	6	W. L. Gilmore..	5.00
"	6	W. B. Warren..	5.00
"	6	W. E. Killen...	5.00
"	6	J. J. Ewing.....	5.00
"	6	C. M. Muchnic.	5.00
"	6	Wm. Garstang..	5.00
"	6	F. M. Twombly.	5.00
"	6	I. N. Kalbaugh.	5.00
"	6	J. E. Keegan...	5.00
"	6	G. L. Dickson..	5.00
"	6	S. M. Vauclain.	5.00
"	6	A. B. Johnson..	5.00
"	6	F. F. Gaines....	5.00
"	6	Jno. Gill	5.00
"	6	R. B. Kendig...	5.00
"	6	G. W. Rhodes..	5.00
"	6	H. N. Breneman	5.00
"	6	G. W. Cushing.	5.00
"	6	F. M. Whyte.....	5.00
"	8	L. H. Turner...	5.00
"	8	S. Higgins	5.00
"	8	B. Haskell	5.00
"	8	R. H. Soule....	5.00
"	8	R. J. Gross.....	5.00
"	8	E. V. Sedgwick.	5.00
"	8	W. F. Yergens..	5.00
"	8	L. C. Noble....	5.00
"	9	F. D. Casanave.	5.00
"	9	W. W. Atterbury	5.00
"	9	J. T. McGrath..	5.00
"	9	R. F. Hoffman.	5.00
"	9	Jas. McNaughton	5.00
"	9	J. E. Gould.....	5.00
"	9	J. Gauthier	5.00
"	9	P. M. Hammett	5.00
"	9	H. S. Hayward.	5.00
"	9	Geo. Wagstaff .	5.00
"	9	S. L. Kneass...	5.00
"	9	A. M. Waitt....	5.00
"	9	Willard Kells ..	5.00
		Carried forward	$ 685.00

		Brought forward .....$	685.00
July	9	A. L. Studer....	5.00
"	11	T. G. Fergusson	5.00
"	12	F. W. Morse...	5.00
"	12	E. N. Weist....	5.00
"	12	W. H. Nuttall..	5.00
"	12	A. Forsyth	5.00
"	12	F. C. Cleaver...	5.00
"	12	A. J. Cromwell.	5.00
"	12	W. E. Dunham.	5.00
"	12	Wm. O'Herin..	5.00
"	12	T. A. Foque....	5.00
"	12	J. H. Manning.	5.00
"	12	W. A. Nettleton	5.00
"	12	F. W. Brazier..	5.00
"	12	J. B. Barnes....	5.00
"	12	G. W. West....	5.00
"	12	A. G. Leonard..	5.00
"	12	S. P. Bush.....	5.00
"	12	A. Turner	5.00
"	12	Henry Bartlett .	5.00
"	12	F. Hedley	5.00
"	12	C. H. Davis....	5.00
"	12	J. A. Pilcher...	5.00
"	12	M. Robinson ...	5.00
"	12	J. L. Lawrence.	5.00
"	12	J. C. Nolan.....	5.00
"	12	J. A. Hill.....	5.00
"	12	P. H. Reeves...	5.00
"	12	W. L. Harrison.	5.00
"	12	H. C. Van Buskirk	5.00
"	12	Mord Roberts .	5.00
"	12	G. N. Riley.....	5.00
"	12	W. H. V. Rosing	5.00
"	12	J. E. Sague.....	5.00
"	12	J. G. Neuffer....	5.00
"	12	Thos. Millen ..	5.00
"	12	P. H. Peck	5.00
"	12	H. Monkhouse .	5.00
"	12	W. H. Marshall	5.00
"	12	W. H. Stocks...	5.00
"	14	Jas. Macbeth ..	5.00
"	14	G. Lanza	5.00
		Carried forward .....$	895.00

		Brought forward .....$	895.00
July	14	E. J. Smith.....	5.00
"	14	W. S. Galloway.	5.00
"	14	L. L. Dawson...	5.00
"	14	F. W. Lane.....	5.00
"	14	H. A. Gillis....	5.00
"	14	P. Maher	5.00
"	14	A. G. Machesney	5.00
"	14	Jno. Mackenzie..	5.00
"	14	J. B. Gannon...	5.00
"	14	G. R. Henderson	5.00
"	14	W. B. Leach....	5.00
"	14	D. O'Leary	5.00
"	14	W. T. Thompson	5.00
"	14	E. B. Thompson	5.00
"	14	H. B. Ayers....	5.00
"	14	W. H. Wilson..	5.00
"	14	G. W. Wildin..	5.00
"	14	E. D. Bronner..	5.00
"	14	E. E. Davis....	5.00
"	14	J. A. Carney....	5.00
"	14	K. P. Alexander	5.00
"	14	P. Wallis	5.00
"	14	H. L. Leach....	5.00
"	14	Geo. Gibbs	5.00
"	14	J. A. Graham..	5.00
"	14	A. J. Dunn.....	5.00
"	14	J. J. Monahan..	5.00
"	14	C. J. Bushmeyer	5.00
"	14	W. G. Menzel..	5.00
"	18	J. B. Michael...	5.00
"	18	F. H. Clark....	5.00
"	18	M. Dunn	5.00
"	18	F. A. Delano ..	5.00
"	18	W. W. Leaman	5.00
"	18	T. E. Keyworth	5.00
"	18	W. S. Hancock.	5.00
"	18	T. H. Curtis....	5.00
"	18	P. T. Lonergan.	5.00
"	18	J. R. Gould.....	5.00
"	18	J. F. Walsh....	5.00
"	18	W. Whyte	5.00
"	18	Wm. Jennings .	10.00
"	18	J. C. Hayden...	5.00
		Carried forward .....$	1,115.00

		Brought forward	$1,115.00
July	18	Jno. Horrigan ..	5.00
"	18	F. J. Smith.....	5.00
"	18	W. J. Wilcox...	5.00
"	18	D. E. Cassidy...	5.00
"	18	M. J. Drury....	5.00
"	18	J. H. Clark.....	5.00
"	18	Henry Elliott ..	5.00
"	18	Robt. Moran ...	5.00
"	18	J. W. Addis....	5.00
"	18	D. F. Crawford	5.00
"	18	J. J. Tomlinson.	5.00
"	18	W. J. Tollerton.	5.00
"	18	C. H. Wiggin...	5.00
"	18	Thos. Booth ...	5.00
"	18	A. J. Pitkin....	5.00
"	18	C. H. Welch...	5.00
"	18	M. R. Coutant..	5.00
"	18	Jno. Taylor	5.00
"	22	H. F. Ball.....	5.00
"	22	E. F. Needham.	5.00
"	22	J. E. Goodman.	5.00
"	22	H. Lopez Aldana	5.00
"	22	Angus Sinclair .	5.00
"	22	L. B. Rhodes..	5.00
"	22	A. E. Manchester	5.00
"	22	J. E. McConnell	5.00
"	22	F. R. Cooper...	5.00
"	22	F. H. Scheffer..	5.00
"	22	T. H. Symington	5.00
"	22	J. S. Pearce....	5.00
"	22	T. W. Demarest	5.00
"	22	J. R. Groves...	5.00
"	22	R. D. Smith....	5.00
"	22	J. A. Egan.....	5.00
"	22	J. Piccioli	5.00
"	22	Ben Johnson ..	5.00
"	22	D. Holtz	5.00
"	22	J. H. Fildes....	5.00
"	22	R. E. French...	10.00
"	22	Wm. Thow	15.00
"	22	C. E. Rettew...	5.00
"	22	R. D. Hawkins.	5.00
"	22	F. A. Casey....	5.00
		Carried forward	$1,345.00

		Brought forward	$1,345.00
July	22	P. D. Park.....	5.00
"	22	H. S. Bryan....	5.00
"	23	T. W. Macfarlane	10.00
"	23	T. M. Markle...	5.00
"	23	A. W. Gibbs...	5.00
"	23	A. S. Vogt.....	5.00
"	23	Jno. McGie	5.00
"	23	J. K. Brassell..	5.00
"	23	W. F. Kapp....	5.00
"	28	A. B. Minton...	5.00
"	28	J. E. Irwin.....	5.00
"	28	Wm. Schlafge .	5.00
"	28	E. W. Pratt....	5.00
"	28	W. K. Christie.	5.00
"	28	G. J. Churchward	5.00
"	28	Geo. Whale	5.00
"	28	W. J. McLean..	5.00
"	28	W. F. Post.....	5.00
"	28	Jno. W. Cloud..	5.00
"	28	Wm. Renshaw .	5.00
"	28	J. S. Booth.....	5.00
"	28	F. M. Fryburg..	5.00
"	28	Jno. Hair	5.00
"	28	R. J. Farrell....	5.00
"	28	W. C. Walsh...	5.00
"	28	A. E. Mitchell..	5.00
"	28	W. H. Brehm..	5.00
"	28	J. J. Sullivan...	5.00
"	28	R. P. Schilling.	5.00
"	28	J. E. O'Hearne.	5.00
"	28	C. H. Seabrooke	5.00
"	28	H. T. Herr.....	5.00
"	28	Geo. James	5.00
"	28	W. H. Hudson.	5.00
"	28	Jno. O'Brien ...	10.00
"	28	F. E. Davisson.	5.00
"	28	W. L. Kellogg..	5.00
Aug.	3	Bert Hartigan .	5.00
"	3	J. F. Dunn.....	5.00
"	3	H. B. Hunt.....	5.00
"	3	E. M. Lake.....	15.00
"	3	F. Hufsmith ...	5.00
"	3	J. S. Chambers.	5.00
		Carried forward	$1,580.00

Brought forward			$1,580.00
Aug.	3	A. J. Cota.....	5.00
"	3	I. W. Fowle....	5.00
"	3	W. F. Bradley.	10.00
"	3	H. J. Small.....	5.00
"	3	Jno. Medway ..	5.00
"	3	W. O. Johnson.	5.00
"	3	T. E. Adams...	5.00
"	3.	W. W. Rickard	5.00
"	3	Jno. S. Cook...	5.00
"	3	A. R. Kipp.....	5.00
"	4	D. M. Pearsall.	5.00
"	4	W. F. M. Goss.	5.00
"	4	Wm. Fuller	5.00
"	4	F. Mertsheimer.	5.00
"	4	Allen Vail	5.00
"	4	R. L. Ettinger..	5.00
"	6	H. M. Pflager..	5.00
"	6	W. T. Smith...	5.00
"	6	A. B. Todd.....	5.00
"	6	W. H. Lewis...	5.00
"	6	Beriah Warren.	5.00
"	6	A. L. Humphrey	5.00
"	16	W. H. Traver..	5.00
"	16	Wm. Kelly	5.00
"	16	Tracy Lyon ...	5.00
"	16	Robt. Quayle ..	5.00
"	16	T. W. Heintzleman	5.00
"	16	W. R. McKeen, Jr.	5.00
"	18	C. E. Uddenberg	5.00
"	18	J. E. Muhlfeld.	5.00
"	18	F. J. Leigh.....	5.00
"	18	H. H. Vaughan.	5.00
"	18	W. P. Hobson..	5.00
"	18	H. T. Thomas..	5.00
"	18	Wilbur Green .	5.00
"	18	B. P. Flory.....	5.00
"	18	Charles DeGress	5.00
"	18	A. C. Adams...	5.00
"	18	J. J. Waters....	5.00
"	18	D. J. Justice...	5.00
"	18	F. J. Cole.....	5.00
"	18	T. S. Lloyd	5.00
Carried forward			$1,795.00

Brought forward			$1,795.00
Aug.	18	D. Van Aystyne.	5.00
"	18	J. Milliken	5.00
"	18	R. N. Durborow	5.00
"	18	P. H. Murphy..	5.00
"	18	C. H. Doebler..	5.00
"	18	F. B. Morrison.	5.00
"	18	R. H. Briggs...	5.00
"	31	L. M. Kidd....	5.00
"	31	A. Sauter	5.00
"	31	W. A. Smith...	10.00
"	31	L. S. Kinnaird..	5.00
"	31	Le Grand Parish	5.00
"	31	G. R. Joughins.	5.00
"	31	H. A. Lyddon..	5.00
"	31	F. O. Walsh....	5.00
"	31	C. M. Stansbury	5.00
"	31	C. H. Cory.....	5.00
"	31	C. A. Bingaman	5.00
"	31	J. P. Nolan....	5.00
"	31	R. A. Billingham	5.00
"	31	Owen Clarke ..	5.00
"	31	Geo. P. Nutt...	5.00
"	31	E. Ryan	5.00
"	31	Louis Greavan .	5.00
"	31	C. H. Hogan...	5.00
"	31	Wm. E. Knight	5.00
"	31	H. M. Curry...	5.00
"	31	W. F. Dixon...	5.00
"	31	S. Suzuki	5.00
"	31	C. A. Fergusson	5.00
Sept.	8	J. W. Fogg....	5.00
"	8	C. W. Cross....	5.00
"	8	W. J. McLeish.	5.00
"	8	C. H. Barnes...	5.00
"	8	R. A. Johnson..	5.00
"	8	W. S. Clarkson.	5.00
"	12	E. A. Williams.	5.00
"	12	F. T. Slayton...	5.00
"	12	Jno. J. Ellis....	5.00
"	12	Chas. J. Thornton	5.00
"	12	W. N. Best.....	5.00
"	12	T. J. Cutler.....	5.00
"	12	Wm. Smith	5.00
"	16	T. A. Lawes....	5.00
Carried forward			$2,020.00

Brought forward			$2,020.00
Sept.	16	W. Sinnott	5.00
"	16	A. Kearney	5.00
"	16	Alberto Villa-senor	5.00
"	27	Jno. Waddington	5.00
"	27	Jas. Fitzmorris..	5.00
"	27	V. Z. Caracristi.	5.00
"	27	W. S. Morris...	5.00
"	27	G. S. McKee...	5.00
"	27	J. E. Cameron..	5.00
"	27	G. T. Neubert..	5.00
"	27	J. L. Greatsinger	5.00
"	27	J. F. Fleischer..	5.00
"	27	J. L. Nichols...	5.00
"	27	W. D. Robb....	5.00
"	27	Jas. Hardie	5.00
"	27	H. O. Westmark	5.00
"	27	C. R. Hilman...	5.00
"	27	C. M. Babcock..	5.00
"	27	Rufus Hill	5.00
"	27	Robt. Gould ...	5.00
"	28	J. H. Watters..	15.00
Oct.	4	E. C. Bates.....	5.00
"	6	T. S. Lloyd.....	5.00
"	6	Wm. Hassman .	10.00
"	12	J. G. Platt.....	5.00
"	12	B. H. Hawkins.	5.00
"	12	W. L. Austin...	5.00
"	12	R. A. Smart....	5.00
"	12	P. D. Plank....	5.00
"	12	J. H. Waters...	5.00
"	12	P. H. Brangs...	5.00
"	12	T. F. Barton...	5.00
"	12	Jas. Kennedy ..	5.00
"	28	C. W. Stevenson	5.00
"	28	E. Thomas	5.00
"	28	H. D. Gordon...	5.00
"	28	W. E. Amann..	5.00
"	28	Harry Pearse ..	5.00
Nov.	5	C. B. Smith....	5.00
"	5	W. Augustus ..	5.00
"	5	H. T. Bentley..	5.00
"	5	Geo. Hodgins ..	5.00
Carried forward			$2,245.00

Brought forward			$2,245.00
Nov.	5	T. M. Downing.	5.00
"	5	W. C. Hayes...	5.00
"	5	F. G. Benjamin	5.00
"	5	H. O. Westmark	5.00
"	17	C. F. Chase.....	5.00
"	17	Geo. Gilmour ..	10.00
"	17	Wm. Forsyth ..	5.00
"	17	Jas. W. Hill....	5.00
"	17	J. P. Dolan.....	5.00
"	17	W. B. Gaskins.	5.00
"	17	W. H. Richmond	5.00
"	25	T. McNabb	5.00
"	25	A. L. Beattie...	10.00
"	25	W. H. Prender-gast	5.00
"	25	F. A. Givin.....	5.00
"	30	Wm. Allport ..	5.00
Dec.	6	Jno. Hopwood .	5.00
"	6	F. E. Place.....	10.00
"	6	J. B. Morgan...	5.00
"	6	C. M. Taylor...	5.00
"	12	Max Toltz	5.00
"	19	A. W. Twombly	5.00
"	19	Oscar Antz	5.00
"	19	J. P. McCuen .	5.00
"	19	E. A. Miller....	5.00
"	19	H. D. Taylor...	20.00
"	23	R. V. Wright...	5.00
"	23	Wm. Cockfield .	5.00
"	31	T. D. McDonald	5.00
"	31	Wm. Moir	5.00
"	31	G. L. Fowler...	5.00
"	31	L. S. Randolph.	5.00
1905.			
Jan.	11	Truman C. Link.	5.00
"	11	G. F. Wilson...	5.00
"	19	Thos. Jennings .	5.00
"	19	E. P. Mallinson	10.00
"	19	J. C. Shields...	5.00
"	19	A. C. Deverell..	5.00
"	21	C. F. Baker....	5.00
"	30	J. H. Tinker....	5.00
"	30	F. H. Litton....	5.00
Carried forward			$2,485.00

		Brought forward	$2,485.00
Jan.	30	L. M. Kidd.....	5.00
Feb.	9	J. G. Thomas...	5.00
"	9	G. E. Branch...	5.00
"	9	C. W. Mudd....	5.00
"	9	W. J. Bennett..	5.00
"	9	A. Stewart	5.00
"	9	Geo. Gurry	5.00
"	9	J. M. Davies...	5.00
"	9	H. G. Beckhold.	5.00
"	9	Frank Slater ...	5.00
"	9	C. E. Fuller	5.00
"	9	S. K. Dickerson	5.00
"	9	J. S. Patterson.	5.00
"	9	V. B. Lang.....	5.00
"	9	H. E. Passmore	5.00
"	9	A. L. Moler....	5.00
"	9	C. A. Thompson	5.00
"	9	A. M. Whyte...	5.00
"	9	A. Lovell	5.00
"	9	Jno. Player	5.00
"	9	C. F. Street....	5.00
"	9	D. R. Macbain..	5.00
"	9	G. M. Basford..	5.00
"	9	H. C. Manchester	5.00
"	9	R. H. Rogers..	10.00
"	9	W. E. Symons.	5.00
"	9	W. H. Thomas.	5.00
"	9	I. W. Clark....	5.00
"	9	E. T. James....	5.00
"	9	W. O. Thompson	5.00
"	9	J. B. Miller....	5.00
"	9	N. W. Norsworthy	5.00
"	9	J. D. Harris....	5.00
"	16	S. L. Bean.....	5.00
"	16	T. McHattie...	5.00
"	16	M. R. Davis....	5.00
"	16	W. H. Russell..	5.00
"	16	Jas. McDonough	5.00
"	16	Samuel Watson.	5.00
"	16	H. M. C. Skinner	5.00
"	16	L. R. Pomeroy.	5.00
"	16	J. Potton	5.00
"	16	S. N. Woodruff	5.00
		Carried forward	$2,705.00

		Brought forward	$2,705.00
Feb.	16	C. G. Turner...	5.00
"	17	J. W. Marden..	5.00
"	17	M. J. Rogers...	5.00
"	17	G. H. Emerson.	5.00
"	17	C. B. Royal....	5.00
"	17	G. Wirt	5.00
"	17	Jos. Roberts ...	5.00
"	17	J. F. Deems....	5.00
"	17	H. Wade Hibbard	5.00
"	17	C. H. Quereau..	5.00
"	17	J. S. Turner....	5.00
"	25	C. B. Young....	5.00
"	25	W. C. Squire...	5.00
"	25	G. W. Kenney..	5.00
"	25	C. J. McMasters	5.00
"	25	T. B. Purves, Jr.	5.00
"	25	C. M. Mendenhall	5.00
"	25	J. H. Pennington	10.00
"	25	Alfred Williams.	5.00
"	25	G. N. Howson..	5.00
"	25	C. R. Ord.....	5.00
"	25	Jas. Buchanan .	5.00
"	25	Wm. Lachlan ..	5.00
Mar.	2	Harry Pollitt ..	5.00
"	2	Thos. Roope ...	5.00
"	2	A. A. Campbell.	5.00
"	2	C. J. Mellin....	5.00
"	2	S. T. Balkam...	5.00
"	2	Wilson Worsdell	5.00
"	2	R. O. Cumback.	5.00
"	2	M. K. Barnum..	5.00
"	9	Jno. C. Glass...	5.00
"	9	Jas. Ashworth .	5.00
"	9	Geo. W. Stevens	5.00
"	9	W. M. Paul....	5.00
"	9	H. Stillman	5.00
"	10	L. R. Johnson..	5.00
"	17	F. P. Barnes....	5.00
"	17	C. E. Slayton...	5.00
"	17	M. D. Stewart..	5.00
"	17	T. Rumney	5.00
"	17	Geo. D. Brooke.	5.00
"	17	G. W. Butcher..	5.00
		Carried forward	$2,925.00

Brought forward			$2,925.00
Mar.	25	F. A. Chase....	5.00
"	25	Jacob I. Krauss.	5.00
"	30	R. Patterson ...	5.00
Apr.	12	C. H. Prescott.	5.00
"	12	H. T. Peyton...	10.00
"	12	F. B. Smith....	5.00
"	12	W. L. Harrison	5.00
"	22	Wm. Smith	5.00
"	22	T. Monlaverde..	5.00
"	22	S. J. Dillon.....	5.00
"	22	F. W. Mahl....	5.00
"	22	P. C. Rusch....	5.00
"	22	H. E. Walker...	10.00
"	22	D. D. Briggs...	10.00
"	29	Edw. Elden ...	10.00
"	29	H. O. Gossett...	5.00
"	29	R. P. C. Sanderson	5.00
"	29	H. Tandy	5.00
"	29	G. W. Seidell...	5.00
"	29	Thos. Walsh ...	5.00
"	29	D. J. Redding..	5.00
"	29	C. D. Hilferty..	5.00
"	29	W. A. Brown...	5.00
"	29	D. Hawksworth.	5.00
"	29	F. N. Risteen...	5.00
"	29	J. J. Casey.....	5.00
May	10	T. S. Beauclerk.	5.00
"	10	M. B. Parker...	10.00
"	10	J. H. Moore....	10.00
"	10	R. P. Blake.....	5.00
"	10	C. T. McElvaney	5.00
"	10	H. M. Minto...	5.00
"	10	A. H. Watts....	5.00
"	10	Frank Tuma ...	5.00
"	10	Geo. A. Bruce..	5.00
"	10	Thos. J. Cole...	5.00
"	10	L. L. Smith....	20.00
"	10	R. Tawse	10.00
Carried forward			$3,165.00

Brought forward			$3,165.00
May	10	Jno. L. Smith..	5.00
"	10	P. O'Beirne	5.00
"	10	E. W. Burgis...	5.00
"	11	W. L. Calvert..	5.00
"	17	S. M. Dolan....	5.00
"	17	A. G. Turnbull..	5.00
"	17	F. A. Torrey...	5.00
"	17	Jas. Marchbanks	5.00
"	17	Geo. Thompson.	5.00
"	17	J. R. VanCleve.	5.00
"	18	J. R. Morrison..	5.00
"	18	A. Struthers ...	5.00
"	18	J. M. Robb.....	5.00
"	22	F. W. Williams	5.00
"	22	J. M. Dow.....	5.00
"	22	J. R. Spragge...	5.00
"	22	W. T. Foster...	5.00
"	22	Jno. Harrison ..	10.00
"	22	L. D. Gillett....	5.00
"	22	F. L. Bates.....	5.00
"	22	Samuel Shepard.	5.00
"	22	J. W. Roberts..	5.00
"	22	S. T. Park.....	5.00
"	22	I. N. Wilber....	5.00
"	25	J. B. Purdy....	10.00
"	29	W. W. Rickard.	5.00
"	29	W. L. Tracy....	5.00
"	29	Grant Hall	5.00
"	29	J. G. Beaumont.	5.00
"	29	C. K. Bowles...	5.00
"	29	Lester I. Knapp	10.00
"	29	T. F. Brady....	5.00
"	29	Richard English	10.00
"	29	J. G. Clifford...	5.00
"	29	W. T. Fitzgerald	5.00
June	1	W. F. Doonan..	5.00
"	1	F. J. Zerbee....	5.00
"	2	I. M. Malone...	5.00
"	3	H. G. Hudson..	5.00
Total			$3,380.00

THE PRESIDENT: You have heard the Secretary's report. We will now listen to the report of the Treasurer.

TREASURER'S REPORT.

To the President and Executive Committee:

Balance on hand June, 1904		$2,874.80
Received from interest	$79.47	
Received from Secretary	81.02	
		160.49
		$3,035.29
Paid Secretary	$ 500.00	
" Mortgage Bond Company of New York as investment of Wheelock Fund	1,000.00	
		1,500.00
Balance on hand		$1,535.29

ANGUS SINCLAIR, *Treasurer.*

THE PRESIDENT: A motion to refer the reports of the Secretary and Treasurer to the Auditing Committee is in order.

MR. WHYTE: Mr. President, I move that the report of the Secretary and the report of the Treasurer be referred to the Auditing Committee. (The motion was seconded and carried.)

MR. ANGUS SINCLAIR (*Locomotive Engineering*): I have pleasure in announcing that we have with us this morning Mr. Edouard Sauvage, the Chief Engineer of the Western Railroad of France, who was president of one of the sections of the International Railway Congress. I move that Mr. Sauvage be invited to the platform and that the privileges of the floor be extended to him. (Motion seconded and carried and Mr. Sauvage escorted to the platform.)

THE PRESIDENT: The next order of business is the matter of the assessment of annual dues.

THE SECRETARY: At the meeting of the Executive Committee last evening the sum of $5 for annual dues was recommended by the committee as the rate for this year — the same as heretofore.

MR. J. F. WALSH (C. & O. Ry.): I make the motion, Mr. President, that the recommendation of the committee be adopted. (Motion seconded and carried.)

THE PRESIDENT: The next order of business is the election of an Auditing Committee. Nominations are in order.

Mr. A. E. Mitchell (Lehigh Valley), F. M. Whyte (N. Y. C. & H. R.) and Mr. W. H. Owens (Southern R. R.) were severally nominated for the Auditing Committee. (Nominations closed.)

MR. C. A. SELEY (C. R. I. & P.): I move that the Secretary cast a ballot for this Auditing Committee. (Motion seconded and carried.)

THE SECRETARY: I cast a ballot, as instructed, for Messrs. A. E. Mitchell, F. M. Whyte and W. H. Owens, as the Auditing Committee. I would like to say to these gentlemen that the books of the Secretary and Treasurer are here on this desk for their inspection.

THE PRESIDENT: Any unfinished business?

THE SECRETARY: There is no unfinished business, Mr. President.

THE PRESIDENT: New business.

THE SECRETARY: The President has named the following committees: Committee on Correspondence and Resolutions: Mr. J. S. Chambers, Mr. A. E. Mitchell and Mr. F. M. Whyte.

Committee on Obituaries: C. F. Thomas — W. H. Thomas; J. R. Slack — J. H. Manning; G. W. Hepburn — J. F. Walsh; D. S. Cooper — W. F. Kapp; R. H. Gilmour — James McNaughton; T. M. Conlon — A. Stewart; J. M. Boon — William Forsyth.

THE SECRETARY: Mr. President, as has been the custom, the Traveling Engineers' Association has sent a representative here. I have a letter from Mr. W. O. Thompson, Secretary, in which he states that Mr. J. D. Benjamin is the representative of that association to the Master Mechanics' convention. I therefore move that the privilege of the floor be extended to Mr. J. D. Benjamin. (Motion seconded and carried.)

THE SECRETARY: I have a communication proposing for Associate Membership in the American Railway Master Mechanics' Association, Mr. J. L. Replogle, Superintendent of Axle, Forge and Bolt Department of the Cambria Steel Company, of Johnstown, Pa.

The proposition is signed by Mr. R. P. Blake, Mechanical Engineer of the Northern Pacific Railway; Mr. P. Maher, Assistant Master Mechanic, L. S. & M. S. Ry., and Mr. LeGrand Parish, Assistant Superintendent of Motive Power, L. S. & M. S. Ry.

In accordance with the Constitution, this proposition will lie over until the next annual convention.

THE SECRETARY: Mr. President and Gentlemen: In regard to the Secretary's report, covering the matter of representative membership, I am rather inclined to think that some of the members misunderstood my letter asking them to appoint representative members. Several of them, I understand, seem to think that the appointment of a representative member would mean that there would be an increased amount of dues collected every year from the company. That is not the case. The object of the representative membership is simply this: Each year, of course, the active members pay the usual assessment, whatever it may be, generally $5. Should the convention at any time decide to have some experiments or tests made, the cost of making these experiments will be estimated and the cost divided among the representative members, on the basis of the number of hundreds of engines which they represent. It may be that in some years no tests will be authorized by the convention, in which case there will be no assessment to raise money to provide for the tests. During other years three or four sets of tests may be carried on, which would require more money than the Association has in its treasury, and that is one of the objects of the representative membership — that when the Association wishes to conduct a series of tests, there will be means whereby the money can be procured, aside from asking a few railroads to make a gratuitous contribution; the amount would be prorated on the basis of the number of hundreds of engines owned. This method is an equitable way of raising money, so that the expense of conducting any tests would not fall too heavily on any individual company. I make this explanation in regard to my circular letter of May 15.

MR. A. E. MITCHELL (Lehigh Valley): I notice that Mr. Godfrey W. Rhodes has resigned as an active member of this Association. I would like to propose him as an honorary member

of this Association, on account of the past work he has done for the Association, and if it is in order at this time I make that motion.

MR. F. H. CLARK (C. B. & Q.): I second that motion.

THE PRESIDENT: It has been regularly moved and seconded that on account of the valuable services of Mr. Godfrey W. Rhodes to this Association — he not having been a member of the Association for the prescribed limit to entitle him to a life membership — that he be elected an honorary member of the Association. (The motion was carried.)

THE PRESIDENT: The next order of business will be the first paper, "What should be the practice underlying the proper loading of locomotives on the basis of conducting transportation with the greatest efficiency and with least cost — considering all the factors individually?" Mr. C. H. Hogan, of the N. Y. C. & H. R. R. R., is the chairman of this committee and will present the report.

Mr. Hogan presented the report as follows:

REPORT OF COMMITTEE ON "WHAT SHOULD BE THE PRACTICE UNDERLYING THE PROPER LOADING OF LOCOMOTIVES ON THE BASIS OF CONDUCTING TRANSPORTATION WITH THE GREATEST EFFICIENCY AND AT LEAST COST — CONSIDERING ALL THE FACTORS INDIVIDUALLY?"

To the Members:

The committee thinks that this subject may be disposed of in one of two ways: one a most general one which shall be of value only in directing the beginning of the more particular consideration of its certain conditions, and the other to consider the particular conditions. The committee thinks the latter is entirely out of its province and therefore will consider only the former.

The subject requires that there be considered "all the factors underlying the proper loading of locomotives" and because the factors are different for the different conditions of operation and the committee fearing that it was not familiar with all the conditions to be considered in the operation of trains in various parts of the country, or even on different sections of the same railroad, addressed a circular of inquiry to the members asking, "What are the factors that affect the economical loading of locomotives?" The various ideas expressed will be quoted in this

report and a perusal of them will indicate what a hopeless task a committee would have to treat of them exhaustively.

References and a short synopsis of each are given with this report, these having been prepared for the committee by Mr. H. M. Chamberlain, a member of the staff of the Mechanical Engineer of the New York Central.

The important factor underlying the proper loading of locomotives is the length of time which may be used in hauling a train over a controlling section of the road; this controlling section may be an opposing grade, a stretch of single track in an otherwise multiple track line, distance between sidings, etc. As the time may be longer, or shorter, so may the loading of the locomotive be heavier, or lighter. The length of time having been fixed, the next two important factors are the power of the locomotive and the resistance of the train and the items which, in opinion of the members, affect these factors as quoted below.

The power of the locomotive may be calculated with a reasonable degree of accuracy, but without knowing the peculiar conditions of each case it will be impossible to say what allowance should be made for the condition of the locomotives, for the water, the fuel and for the almost innumerable items, some of which need attention in each locality.

The train resistance contains a greater number of variables than enter into the calculations of the power of the locomotive; the number of cars and their condition, track conditions, atmospheric conditions and others. When the rating is very accurate the total tonnage should be ascertained by more accurate means than those prevailing at the present time in many places.

There is a means of checking the calculations of locomotive power and of train resistance — the dynamometer between tender and first car in train, and it is recommended that this be used. Calculations are very well, but it frequently happens that the basis of the calculations is wrong. For instance, the grades may not be what the profile data show; the elevation on curves may have more serious effect than assumed; the resistance per ton and per car may differ from the assumptions, and the locomotive may give results different from the assumed ones.

The operating department and the motive power department ought to take equal interest in the proper loading of locomotives.

Immediately below are given the factors which the members think affect the economical loading of locomotives, and considering the innumerable combinations of them which are possible, not only on different roads, but also on different sections of the same road, the committee thinks that it can not treat of the subject of the report in other than the very general way given in the foregoing. The name of the member making reply and the railroad with which he is connected are given:

A. E. Mitchell, Lehigh Valley R. R.:
Grades.
Curvature.

Condition of locomotive.
Steaming qualities of locomotive.
Quality of coal used.
Quality of water used.
Location of water stations, whether on up grades or levels.
Speed required for fast freight.
Speed required for slow freight.
Proper distribution of time on time-table, so that faster time can be made on levels and descending grades and slower time on up grades.
Condition of cars in each train, whether heavy on side bearings or otherwise.
Size of journals under cars.
Condition of journal lubrication.
Weather conditions.
Conditions of track and rail.

William Garstang, C. C. C. & St. L. Ry.:

Maximum boiler duty that can be depended on, with tonnage confined to a basis of equivalent steam consumption for various speeds.
Scheduled speed between terminals.
Actual speed necessary to make schedule time.
Concentration of tonnage for reduction of flange resistance.
Weather and temperature conditions.

T. W. Demarest, Penna. Lines West, N. W. System:

The character of the motive power.
Transportation facilities as influenced by:

(a) Physical character of the division, having reference to grades and alignment.

(b) Whether it is a single-track railroad or a double-track railroad; passing siding facilities and terminal facilities.

Density of traffic.

Traffic requirements which cover the character of the business, i. e., whether same is a low-class business on which a fast movement is not required, or whether it is a high-class business in which speed is one of the vital requirements. Each division of a system must receive individual analysis with above factors in view. The analysis for one division may or may not apply to the other divisions of a railroad; in general it will not. A further factor, of course, is such motive power facilities as will insure the prompt handling of the locomotives at terminals with a view of increasing the service hours for transportation purposes, and we, finally, have four conditions to be obtained:

1. Maximum service hours for the locomotive.
2. Maximum miles per hour for the locomotive considered as being available for transportation service for each hour of the entire month or year.

3. Maximum miles per hour for the locomotive while available for transportation purposes.

4. Maximum tons per train for each individual train.

J. A. Carney, C. B. & Q. Ry.:

The proper loading of a locomotive is the number of tons of train it can put in and get out of side tracks in a reasonable length of time and haul up maximum grades without doubling, either by running for the grade, if it is short and a stop is not necessary at the foot of the hill, or by a straight pull if the grade is long or a stop necessary at the bottom.

The weight of the train should vary with the number of cars.

Theoretical figures on tonnage rating per tractive force are not reliable, and while they furnish valuable data to base rates on, the local conditions may make them too low or too high. Actual service tests based on theoretical rating give the best results. On a level road the theoretical rating is generally too high and on a hilly road the theoretical rating may be too low where the maximum grade limits the tonnage rating.

W. R. McKeen, Jr., Union Pacific R. R.:

R. Resistance in pounds per ton of train.

V. The miles per hour.

T. The tons in train.

L. The length of train.

C. The number of cars in train, surface exposed to wind.

The correction of temperature is an important one where the temperature varies from 20 degrees below zero to 105 degrees above zero.

The correction for wind is an important one, particularly in level country on the plains where the wind is almost constant and more important than the grade resistance.

If curves are not compensated the same afford a factor for correction.

The drawbar pull of the engine is dependent upon so many variable quantities and so many quantities upon which it is almost impossible to estimate that it would seem the engine capacity should be determined by means of a dynamometer car which would avoid any discussions as to the limit of same.

A. E. Manchester, C. M. & St. P. Ry.:

In my opinion no hard and fast rule can be laid down covering the proper loading of locomotives, except that all of the local conditions in connection with the service be taken into account.

J. F. Walsh, C. & O. Ry.:

Taking it for granted that a locomotive will not be started over a division unless in probably such condition as will enable it to make

a successful round trip, I would say that weather conditions would be the only thing that should affect its hauling capacity; the latter can usually be approximately determined by multiplying the tractive power by the number of thousands of pounds upon the drivers. This rule, we find, will give approximately what a locomotive can haul over a straight level track. In figuring on the resistance due to curvature, we figure that each degree of curvature is equal to a rise in grade of 1½ feet per mile. To determine approximately what an engine will haul up a given grade, we take ⅜ of the number of feet rise in grade per mile, divide that sum into the tractive power, and that will give approximately what an engine will pull up a given grade. Our tonnage rating is determined by actual pulling tests.

G. L. Fowler, Consulting Engineer:

1. Train resistance.
2. Drawbar pull.

The factors affecting the first head include the journal friction, air resistance, grades and number of axles in the train.

The second varies with the tractive power of the engine and the condition of the rail.

In order, then, to allow for the variations in these factors, I would suggest the lading should be so proportioned that, with the train resistance at a maximum, and the drawbar pull at a minimum, the engine should still be capable of taking its load over the ruling grades.

That this may be done and still secure the maximum available load behind the tender, the weight of the trains should be adjusted on a sliding scale in such a way that the tonnage can be increased as the number of axles is decreased. In other words, so that the greater the capacity of the cars the greater the total tonnage.

J. H. Watters, Georgia R. R.:

The factor that affects mostly the economical loading of a locomotive is the one of overloading. A locomotive to do the best work and to show the most economical operation should be loaded with a train with which it can make schedule time over the heaviest part of the road.

C. H. Doebler, Wabash R. R.:

Weather conditions, rail conditions, the ruling grade, time required between terminals, number of trains to be handled over a given piece of track, distance between sidings and distance between coaling and water stations.

A. R. Kipp, Wisconsin Central Ry.:

The economical loading means the minimum cost to haul one ton one mile and is affected by:

Wages, including those of enginemen, trainmen and roundhousemen. This item is more important on single-track roads than on double-track roads, as heavily loaded slow freights are more likely to affect other trains than those on double track. This item is controlled considerably by overtime.

Fuel: There is an economical limit in the consumption of fuel beyond which the expense of operation rapidly increases.

Locomotive repairs.

Number of ton-miles hauled in a given period of time. This involves a question of investment in locomotives and car equipment and the amount of money earned with that equipment.

J. J. Conolly, D. S. S. & A. Ry.:
1st. Condition of locomotive.
2d. Quality of fuel used.
3d. Weather conditions.

E. B. Thompson, C. & N.-W. Ry.:
Moving as much freight as possible.
Time.
Length of division.
Weather.

E. W. Pratt, C. & N.-W. Ry.:
Dynamometer tests.
Condition of power.
Time.
Length of division.
Condition of coal and water.
Weather.

John Heath, C. & N.-W. Ry.:
The basis of rating should be the dynamometer car.

F. G. Benjamin, C. & N.-W. Ry.:
The fundamental principle of loading a locomotive should be based on the question of the most economical load that an engine can haul without the loss of wear and tear on the locomotive, the loss in consumption of fuel and the shortest time on the road. There is no question but what there is good economy in loading an engine to a point where there is a reasonable percentage of reserved power to enable it to handle a train over the heaviest grades and have a measure of reserve to take advantage of inclement weather and high winds; also to take advantage of the road.

T. J. Cutler, Northern Pacific Ry.:
1st. The weather condition.
2d. Speed over the division.

3d. Time on road in regard to overtime paid.

4th. The volume of business and the amount of power available.

5th. The length of passing tracks on the division.

References to literature on the subject and a short synopsis of each follow:

RAILWAY CLUB REPORTS.

No. 1.— Pacific Coast Railway Club, December 19, 1903. (Note. See also reference No. 10.)

"What shall be the maximum economical load for a locomotive." By C. T. Noyes.

An interesting paper tending to show that most economical operation will be made with trainloads under the maximum hauling capacity of locomotives. In the discussion the method of tonnage rating in use on the Southern Pacific Railway is given. The method is based upon time as principal element, and time-load diagrams are gotten out made up from investigated experimental data. These diagrams show relation between train speed, load and engine power.

No. 2.— Western Railway Club, March 17, 1903. (Note. See also references Nos. 8 and 15.)

"Equated Tonnage Rates." By M. H. Wickhorst, Engineer of Tests, C. B. & Q. Ry.

Discussed by G. R. Henderson and William Forsyth.

Gives methods of test and calculation for finding tractive forces, drawbar pulls, train resistances, etc.

Equated tonnage tables are made by balancing the tons trainload which will give a certain total train resistance, with total available tractive power of engine.

Method used in calculating tables is given and sample tables for different grades.

No. 3.— Iowa Railway Club, June 13, 1904. (Note. See also reference No. 7.)

"The Economic Tonnage for a Locomotive." By A. F. Finch and H. Bentley.

Mr. Finch's paper is a short presentation advocating rating of eighty per cent of maximum available drawbar pull under favorable circumstances, as found by dynamometer car.

Favorable results experienced on the C. & N.-W. Ry. by reduction of this rating from one hundred per cent to eighty per cent as above.

No. 4. Canadian Railway Club, February, 1903. (Note. See also reference No. 10.)

"Overloading Locomotives." By Mr. Bury.

TECHNICAL JOURNALS.

No. 5.— *American Engineer and Railroad Journal,* September, 1904, p. 350:

"Economical Train Operation." By G. R. Henderson.

Editorial on article by Mr. Henderson on Economical Train Operation, giving outline of subject.

American Engineer and Railroad Journal, October, 1904, p. 371:

"Economical Train Operation." By G. R. Henderson.

General opposition exists to loading engines in excess of their "efficient rating." This indefinite term is discussed.

Operating Charges: Three items make up about one-third of total operating expense, i. e., supplies, repairs and service.

How to estimate actual value of the several operating charges under general heads of supplies, repairs and service:

(a) Fuel for locomotives: Is largest and most difficult item to estimate. Curves given for reading by inspection the "coal efficiency" of a specified locomotive for different trainloads and speeds.

(b) Water, oil, waste and miscellaneous supplies for locomotives. Only about one per cent of total operating expenses consumed by these items. All, including water in most cases, can be considered upon a mileage basis.

(c) Train supplies. Considered on mileage basis, at 1.5 cents per mile.

(d) Repairs and renewals to locomotives. Arbitrary figure of 8 cents per one thousand ton-miles net, taken as proper figure and method of covering repairs and renewals.

(e) Repairs and renewals to freight cars. Arbitrary figure of 15 cents per one thousand ton-miles net, taken as proper figure and method of covering repairs and renewals.

(f) Wages of enginemen and firemen. Scale of prominent Western road is used.

(g) Wages of trainmen. Scale of prominent Western road is used.

(h) Wages of roundhouse men. $2 for each time engine is housed to cover this charge.

(i) Interest charges on locomotives and caboose, 10 cents per hour.

American Engineer and Railroad Journal, November, 1904, p. 411:

"Economical Train Operation." By G. R. Henderson.

An arbitrary division of road of 150 miles in length with uniform up grade of one per cent is considered, and costs of the several items above for speeds between five and twenty-five miles per hour, inclusive, are tabled.

Conclusion for above division: "If engine is loaded so that it can and does make a running speed of 15 miles per hour, with side track, etc., delays, approximating twenty per cent of the running time, or an average speed between terminals of 12½ miles per hour, the greatest volume of traffic will be moved and at lowest rate per ton-mile for expenses and least amount of coal per ton-mile hauled will be consumed."

Similarly operating charges are tabled, considering a road division of 150 miles in length, half up grade of one per cent and half down grade of one per cent.

American Engineer and Railroad Journal, December, 1904, p. 453:
"Economical Train Operation." By G. R. Henderson.

Thirdly, a 150-mile division is considered of undulating profile with less per cent of grade and with a lighter locomotive, the latter being permissible by easier road conditions.

American Engineer and Railroad Journal, January, 1905, p. 11:
"Economical Train Operation." By G. R. Henderson.

Deductions and conclusions: In all three cases considered, greatest economy is found at an average speed of operation of 12 to 15 miles per hour.

No. 6.—*Railroad Gazette,* November 25, 1905, p. 165, G. N. S.:
"Economy in Moderate Loads."

Article taken from the *Wall Street Journal* showing good results from reducing trainloads on C. R. R. of N. J.

No. 7.—*Railroad Gazette,* July 15, 1904, p. 31, G. N. S.:
"Overloading."

An abstract of Mr. Finch's paper before Iowa Railway Club. June 13, 1904.

No. 8.—*Railroad Gazette,* April 8, 1904:
"A Formula for Tonnage Rating."

Is a contribution by G. R. Henderson, giving data same as presented in G. R. Henderson's discussion of Mr. Max Wickhorst's paper before Western Railway Club, of March 17, 1903.

No. 9.—*Railroad Gazette,* March 25, 1904:
"Combined Car and Tonnage Basis."

A contribution by A. L. Kuehn, treating particularly on journal frictional resistance allowances in making up tonnage ratings.

No. 10.—*Railroad Gazette,* February 5, 1904, p. 99; April 1, 1904, p. 249:
"Maximum Economical Load."

An abstract of and a discussion on Mr. Noyes' paper before Pacific Coast Railway Club, December, 1903, later by J. V. N. Cheney.

No. 11.—*Engineering News,* December 15, 1904, p. 537:
"Diagram for Fuel Consumption." By G. R. Henderson.

Paper read before American Society of Mechanical Engineers at New York city, New York, December, 1904. Gives formulæ for tractive force, drawbar pull, etc., and diagram of curves of coal consumption and boiler evaporation for a specified consolidation engine.

No. 12.—*Engineering News,* March 31, 1904, p. 310:
"Ton-mile Cost on 'Bessemer' Road for 1903."

A short article on low ton-mile cost.

No. 13.—*American Engineer and Railroad Journal,* June, 1904, p. 205:
"Locomotive Failures and Overloading."

A series of questions on modern big engines, engine failures and engine loading answered by leading officials of several prominent railroads.

No. 14.—*American Engineer and Railroad Journal,* June, 1904, p. 226:
"Locomotive Failures and Overloading."

Editorial on same.

No. 15.—*American Engineer and Railroad Journal,* July, 1904, p. 254:
"Adjusting Tonnage Rating, Simple Method of." By H. H. Vaughan.

A contribution on the paper and discussion by M. H. Wickhorst and G. R. Henderson, latter before Western Railway Club, March 17, 1903; gives an analysis of some points presented in that report.

No. 16.—*American Engineer and Railroad Journal,* April, 1904, p. 155:
"Overloading Locomotives." By G. J. Bury, G. S., C. P. Ry.

For dense traffic load should be such that speed will be at least 15 miles per hour for best results and economy.

"While theoretical tests are all right for a basis upon which to work, the only way to arrive at the engine load is by actual tests in practice."

No. 17.—*American Engineer and Railroad Journal,* March, 1904, p. 100:
"Locomotive Failures and Loads."

Short editorial on same.

No. 18.—*Railroad Gazette,* March 1, 1895:
"Equated Tonnage Rating." By L. G. Haas.

Used on Penna. Lines West of Pittsburgh.

RAILWAY CLUB REPORTS.

No. 19.— Western Railway Club, December 17, 1901, p. 128:
"Locomotive Rating." By D. F. Crawford.

No. 20.— New York Railroad Club, January 20, 1898, p. 3:
"Tonnage Rating." By L. R. Pomeroy.

Gives various methods in use for rating locomotives; C. H. V. & T. Ry.; Northern Pacific Ry.; Chicago Great Western Ry.; Southern Pacific Ry. Gives also graphical methods for equating ton-load resistance with engine power.

ENGINEERING SOCIETY REPORTS.

No. 21.— Proceedings American Railway Master Mechanics' Association, for 1904.
"Committee on Coal Consumption of Locomotives." By H. T. Herr, Chairman.

In appendices to report is given an outline of the fundamental principles of the above papers by Mr. Haas and Mr. Crawford, in their treatment of subject of locomotive loading by equating known or computed train resistances to known or computed locomotive powers. Graphical methods are used and curves plotted between trainloads, resistances, weights of cars, etc., to provide ready means of matching trainloads, made up of cars variously loaded, with the locomotive power available.

C. H. HOGAN, Chairman.
H. T. HERR,
D. F. CRAWFORD,
H. T. BENTLEY,
Committee.

DEPEW, N. Y., April 20, 1905.

MR. HOGAN: Gentlemen: No doubt you fully realize what a difficult matter it would be, and is, for a committee to prepare a satisfactory report on a subject of this nature, one as important as this subject. Inasmuch as your committee was unable to secure a dynamometer car and other facilities at the time to make such tests as should be made, we sent out a circular letter to all of the members, asking "What is the factor that affects the economical loading of locomotives?" to which, I must say, hearty response was made. I wish the answers could all have been printed. It is our opinion that the dynamometer car should be used in these tests and the train tests should be made afterward to determine

the resistances of curves and grades, and it is our opinion that where locomotives are rated at, say, 3,000 or 3,500 tons, and that where that tonnage can be placed in seventy-five cars, it has been determined on some roads that that 3,500 tons can be hauled easier in seventy-five cars than in eighty-five cars; but all these matters are very satisfactorily determined by the dynamometer cars and practical tests following.

THE PRESIDENT: The paper is now before you for discussion. The question of locomotive rating is always very interesting. We find that sometimes the way they rate them in the West is for the Master Mechanic to put a tonnage on the locomotive, the superintendent adds more, the trainmaster adds more, and when it comes to the general manager, the train is loaded, but not economically.

MR. ANGUS SINCLAIR: I move that the report be received and opened for discussion. (Motion seconded and carried.)

MR. W. G. WALLACE (Duluth, Missabe & Northern R. R.): The subject is, What shall be the principle underlying the proper loading of locomotives? This is a difficult thing to handle or for a committee to make a report on which would be suitable for all the different railroads. If there is to be no discussion of this, I should think it would be well for the Association to recommend that locomotives should have an established rating that would permit proper train movement and avoid delays to following or opposing trains, lay-outs at meeting points, etc. The rating should be governed by the amount of traffic and the importance of the trains, and determined by the operating officer and the representative of the locomotive department, thus enabling all engines in service to produce the highest revenue, and as a fixed rating would not be applicable to the different conditions, the rating should be left to the respective officers of the road or division on which the locomotives are employed. I do not believe we could give an established rating here for the locomotives that would be applicable to all the different classes of service. It is something that the respective men on the divisions will have to work out for themselves.

MR. J. F. DEEMS (N. Y. C. & H. R. R. R.): I fully agree

with what the gentleman has said. This subject reminds me of the farmer who said he wanted to buy more land, and when he was asked why he wanted to buy more land he said it was to raise more hogs. He was then asked why he wanted to raise more hogs, and he said it was because he wanted to be able to buy more land. In my opinion you could thresh this subject for the next four sessions, and at the end of the discussion you would be practically where you started.

MR. H. H. VAUGHAN (Canadian Pacific Ry.): When this subject was selected, I had an idea that when the report was presented the whole subject would be threshed over with a view of bringing out some discussion as to whether the excessive length to which tonnage rating has been carried was really economical. I mean the loading of engines to a point where the time taken is exceedingly long for a division. The report does not touch on that feature to any great extent, and it would be rather interesting if we had some information from a number of roads as to what percentage of the maximum tonnage that actually could be handled by the engines is being handled or allotted to the engines on their rate sheets. I think a comparison of that nature would have been interesting to show the practice which the roads are tending to in gradually finding out what they consider their economical tonnage. I have an idea that the complaints that have been made against very heavy tonnage are largely, on the motive power side, from a desire to avoid troubles. Provided an engine is not taking an excessively long time, it appears to me economical to keep the tonnage up pretty high or to a point where under good conditions an engine can handle that tonnage, and not to reduce it say ten or fifteen per cent simply to be absolutely sure that an engine is always going to handle it. Of course, that proposition itself depends on the nature of the traffic on a line, whether the traffic is very important, or whether delay does not cause any serious inconvenience, but except upon sections where there is either a long steady grade, or an apparently level section, so that the engine is working fairly well to its capacity over a large percentage of the division, I should think we would find that the time taken over the division is much more a transportation department question than a motive power department.

On an undulating road, where there is probably not over fifteen or twenty per cent grade on a section, an engine, however loaded — provided its loads can be handled over the limiting grades — can generally make any desired rate of speed over the division, provided it is not laid out or held at crossing points. The speed over the division can be regulated by a reduction put into force occasionally, when required by conditions of exceedingly heavy track or congested business, by winter conditions, or anything else that is causing undue detentions, to a point where the train is handled at fairly economical speeds.

By discussions we have agreed on putting it at from ten to fifteen miles an hour, and my feeling in the matter is that outside of roads where there is a considerable length of grade on a division, or a very level division, that really the heavier we load the engines the better, provided the transportation department is not causing undue delays in handling the traffic.

One thing I have noticed in this report with some interest is the fact that a large number of the members replying referred to the condition of engines as a factor in the tonnage rating. I attempted some time ago to get some information with reference to what allowance the different roads were making in their tonnage rating for the condition of the power, and the three or four roads to which I wrote gave no definite answer. I consider that it would be very interesting in connection with this report to ascertain if any roads are using definite reductions on account of the condition of their power. We make no reduction. We expect an engine to be in condition to haul the tonnage. Of course, it is not always in condition to haul the tonnage, but that is the assumption; and if there is any failure it is sent in as an engine failure to haul tonnage and referred to the superintendent. I have not worked the thing out, but think it would be interesting to work it out, whether it really is economical to shop an engine at a point where she begins to fall down on the tonnage, or whether it would not be profitable to put in a B or secondary rating for an engine which has made seventy-five per cent of the mileage she could make, and give the engine a reduced tonnage. I am interested in learning whether any such practice is carried on on any of the roads. Offhand, I would consider it a good

thing. We frequently shop engines, at the beginning of the winter, from which we could get more mileage if we were enabled to use a reduced rating for the engines that were in fair or poor condition, and the engines would be able to go along in many cases for a month or two longer before having to be brought in.

MR. G. R. HENDERSON: In regard to the question asked by Mr. Vaughn, my recollection is that in a report made by a committee several years ago, there was a statement, in the body of the report, relating to one or two roads, which made a custom of reducing the engine rating according to the length of time the engine was out of the shops. It seems to me that what militates against the real subject of this paper, which is concerning the conducting of transportation at greatest efficiency and least cost, are primarily two things: One is the fact that the schedule for time and tonnage loading is made up by the transportation department, very often without going into the matter thoroughly with the motive power department; and I do not think, as a rule, the transportation officials have the information or data necessary to work up the load and speed combination needed to give least cost and greatest efficiency. Then there is a second point: Some high officials have an idea that there is nothing better than a high tonnage, and the division superintendent who hauls the greatest number of tons usually receives commendatory letters; whereas, another superintendent may be transporting his freight at a less cost per mile, and yet if his trains are lighter by, say, ten or twenty tons, he may not get the complimentary letters which were sent to the other man. I think these two things militate against getting the best results.

MR. F. H. CLARK (C. B. & Q.): As far as I know, Mr. Chairman, we make uniform reductions for engines that are not capable of hauling full tonnage on account of condition. I think that allowances are made on some divisions for such engines. I think that the economical rating of an engine will be with a load with which it can make ten to fifteen miles an hour. I do not think there is any economy in loading an engine so that it can not make ten miles or more an hour; because at a speed less than ten miles an hour we are not only using a good many engines to get our tonnage over the road, but overtime usually begins at that point, and that has quite an effect upon the general result.

I think perhaps, as a general thing, we do not take a broad enough view of the cost of operating trains. We are likely to lose sight, for instance, of the wages of the trainmen. The economical rating of engines is perhaps somewhat higher than what we have been accustomed to regard it.

MR. ANGUS SINCLAIR: I think the members might feel interested in hearing of the principles on which they regulate locomotive loading in Europe; and I would therefore suggest, Mr. Chairman, that we ask Mr. Edouard Sauvage to give us the practice in Europe.

MR. EDOUARD SAUVAGE (Western Ry. of France): Mr. Chairman, the principles which are generally used in Europe would be a little too large a question for me to handle in this way; but I will confine myself to making some remarks about France, as I am more conversant with French railroads.

The general principles are as follows: First, as to the grade of the line; we do not take the actual grade, but a certain fictitious grade, which is chosen according to certain circumstances. If there is a very short, heavy grade, say, one in sixty or one in seventy, that is not taken into consideration. If the grade is not short, of course it must be considered. So, we have a classification based on that fact. And then different lines are classified according to the difficulties of hauling up the ruling grade. When that is done the regular tonnage of each class of engine is fixed on each section of the line. That is not necessarily the maximum tonnage the locomotive can take, but it is the regular tonnage, and the locomotive department is not obliged to take more. But in cases where they think it is possible to haul more — say, the fireman, or even the engine driver, thinks he can haul more when the weather is fair and the engine is in good condition and when the quality of the coal is assumed to be good — then they may take extra weight; and they are incited to do that by a premium which they are allowed.

There is a certain allowance of coal for engine drivers; and if they burn less there is a premium allowed to them for that economy. That is calculated for the regular weight, and again for extra weight cases, and in extra weight cases they have an extra allowance; but they are not obliged to do this when the

weather is bad or there are any difficulties in haulage. That gives the general feature of the French system.

If you take everything into consideration, I believe there is a tendency not to have the engines rated too high in France. When the engine is rated too high, the coal consumption goes up; so the ordinary rating is a moderate one, and they are allowed to take extra weight at times. It is, therefore, you see, a difficult question to give an exact and definite answer to. I beg, therefore, that you will excuse me for not going into this subject any further.

In ending my remarks, I wish to say that I feel grateful to you for allowing me to state our practice in this assembly of very competent and very practical men.

MR. THEODORE H. CURTIS (L. & N. Ry.): Our practice is based on the actual test of the locomotives on the different divisions. We make no allowance whatever for the condition of the engine. The engine is supposed to haul full tonnage at all times. We do make an allowance for weather conditions.

MR. A. E. MANCHESTER (C. M. & St. P.): Mr. Chairman, I did not get into the room until this discussion had started, and I am not clear as to what has been said on the subject, but as to the practice on the road by which I am employed, in relation to loading and rating of trains, I will say we determine what is the maximum loading for an engine by dynamometer test. I do not believe that is the best way to arrive at the proper and economical method of handling trains. The dynamometer test is given to the yardmasters or superintendents of terminals, who use this as their rating of load for the engines. It invariably represents the maximum power of the engines under favorable conditions. I like better some of the statements made in the report of the committee, wherein they recommended eighty per cent of the maximum of the engine as a standard loading, or, as referred to in the report from one of the railroads, taking the maximum power of the engine and the maximum draft of the train and loading the engine from this basis.

I note that reference has frequently been made to the condition of the engine. The method we are undertaking to bring about to arrive at determining the condition of the engine for per-

forming its maximum work, is by having the division superintendent keep a daily check on the coal. The train dispatcher receives for each train a ton-mileage statement when the train arrives at its terminal. He also receives from the motive power department a statement of the number of pounds of coal taken by that engine on that trip. He gets this statement almost as quickly as the engineer has taken off his working clothes. He immediately puts into figures how much that engine has used per one hundred tons hauled per mile on that trip.

Now, if the performance of that particular engine in the making of time or the consumption of coal on the trip is bad, that is a mark placed against that engine; and if that same performance is repeated three or four different times, then the motive power department is called into requisition to determine why it has been a bad coal performer, and our observations are that whenever the engine is not a good tonnage handler, or time maker, that department is told that the engine is in that condition, and right then and there we apply the remedy so far as that engine is concerned.

Returning to what I first referred to, as to what should be the standard tonnage rating for a train, I would make it on the lines I have already referred to; that is, either eighty per cent of the maximum under favorable conditions; or, taking the minimum power of the engine under all variable conditions, and the maximum draft of the train under the several conditions that have been found, and rate it from those two points. That would give a train that could be handled over the road at eight or ten miles an hour as a minimum at its ruling grade.

I believe a strong factor in the operation of railway trains is the man behind the gun. We have heard of that a good deal in other lines in the last few years, and I believe on railroads that is the great factor — the man behind the gun. And I have thought, while it has not been entirely put into practice with us, that the method to be employed should be that a train should be started out of a terminal station — the engine's performance for the trip undetermined, the draft of the train undetermined, using possibly the eighty per cent of the maximum rating to start with, when the train has been handled a few miles, however, have a filling-up

point, and then be so in touch with the man behind the gun that when he arrives at this point, he says, "I want twenty or thirty per cent more tonnage." The man is interested or can be made interested in the economical performance of the work he is doing, and when he understands, as he can easily be made to, that it is only by handling tonnage that he can make an economical showing for his engines and his division, he can be got into line and will show that he wants this additional tonnage at the filling-up point. In other words, if he has a train which is extremely hard at the start, he can work as economically as he can with that train, and as quick as he finds a favorable condition in which he might do much better, he comes to the front and asks for something to make that particular train an economically handled train.

MR. DAVID BROWN (D. L. & W. R. R.): I think our present methods and rules for getting proper tonnage are very good. I think it is our duty to take the tonnage rating at all times, excepting under unusual weather conditions — snow on the track, etc. When there is snow on the track, the rating should be cut down a certain percentage. I think a great many of us look rather hard at some little matter that will keep an engine in proper condition to handle her full tonnage. If the valves and pistons are looked after and kept in good condition, we will find some difference in the coal bill, and it will give the engineer a chance to see that his engine does its work and hauls its proper tonnage. I do not think it would be good policy to discriminate on an engine's tonnage because it is out of condition. It should be put and kept in good condition.

MR. F. M. WHYTE (N. Y. C.): Mr. Manchester has suggested that the engineer, fireman and the train crew could be made interested in the economical handling of their engine; a good way to do that is to pay them on a tonnage basis. The pay is now based on mileage. Such a practice was followed in England years ago, and also the enginemen were compelled to purchase the coal used, making the purchase from the company.

THE PRESIDENT: Is there any further discussion on this paper? If not, the next is the report on Locomotive Tests of the Pennsylvania R. R. at the St. Louis Exposition. Mr. F. H. Clark is chairman of the committee.

Mr. Clark read the following report:

REPORT OF COMMITTEE ON LOCOMOTIVE TESTS OF PENNSYLVANIA RAILROAD AT ST. LOUIS EXPOSITION.

To the Members:

The members of your Association, appointed in 1903, at the request of the Pennsylvania Railroad System, to serve on their advisory committee in connection with the locomotive tests to be undertaken at St. Louis, beg to report that the tests of eight engines were completed, and that the data has been worked up and will soon be in the hands of the printers. It was found impossible to test as many engines as was intended, owing partly to delays in the arrival at St. Louis of a part of the testing plant equipment, and partly to unexpected difficulties in breaking in the plant.

We feel that the members of this Association are more or less familiar with the work done on this plant and appreciate the earnest and careful work done by the staff of the Pennsylvania Railroad engaged on these tests, but your committee wishes to record its appreciation of the energetic and thorough method in which the tests have been carried out, and to call attention to the immense amount of work involved in working up the data obtained.

It was not to be expected that in the limited time available it would be possible to settle all of the important problems of locomotive design in which we are so much interested, but we believe that a careful analysis of the final report will indicate that a great deal has been done in this direction, but that more perhaps has been accomplished in the direction of suggestions for future work and investigations. The report of the committee will probably be published in three or four months.

We regret that we are not in a position to make a final report at this meeting, as the work of the committee is not yet completed, but expect to do so at next year's meeting.

F. H. CLARK,
H. H. VAUGHAN,
C. H. QUEREAU,
Committee.

CHICAGO, ILL., June 7, 1905.

MR. F. H. CLARK: I have simply to add to this report the statement that the work of the committee was concluded at a meeting held in Philadelphia last Monday; that the material will all be in the hands of the printer in a very few days, and, as indicated in our report, the final report will be out in two or three months.

MR. J. CHRISTOPHER (Toronto, Hamilton & Buffalo Ry.): How are the members to get this report when it is printed?

MR. G. R. HENDERSON: I assume that the report will be published in book form and the gentleman will be able to get it after it is printed.

MR. CHRISTOPHER: That is my idea. It is an interesting subject and if it is to be up before the next annual meeting we can get it then.

THE PRESIDENT: The committee will certainly make a report to this Association at the next meeting.

MR. F. H. CLARK: We, of course, can not give out the results of these tests until the report is published by the Pennsylvania Railroad Company. They propose to get it out in book form, and I believe that our members will be able to get copies of it. As to our final report, I can only say that we hope to get out a satisfactory report, but I am unable to say in just what form it will be made.

MR. ANGUS SINCLAIR: I make the motion that the report on these tests be received and the committee continued for another year. (Motion seconded and carried.)

THE PRESIDENT: We have now reached the noon hour, and the order of business is the discussion of topical subjects, the first one of which is, "The best known dimensions for water space around fire boxes to produce maximum consumption of fuel and replacement of fire-box sheets; and reasons for the same." To be opened by Mr. Lawford H. Fry.

MR. LAWFORD H. FRY (Baldwin Locomotive Works): In endeavoring to discover what is known on this subject, I made an examination of the water-space dimensions of some eighty-four modern boilers. The figures obtained show a wide variation in practice. Among the wide fire box engines the narrowest water space measured as follows: Front leg, 4 inches at mud ring and 5 inches at throat; side and back legs, 3 inches at ring and 4 inches at crown. The widest space had a front leg measuring 5 inches top and bottom; side legs, 5 inches at ring and 6 inches at crown; back leg, 5 inches at ring and 7½ inches at crown.

This investigation showed that there is no generally recognizable rule connecting the size of the water space with the fire box dimensions, but that there is an increasing tendency to use wider water spaces. So many reasons for the use of wide water spaces can be brought forward that it appears strange that the width has not been increased more rapidly. When the fire boxes were restricted in width by being placed between the wheels, the necessity of obtaining all possible grate area made it desirable to keep down the width of the water spaces to a minimum. Now, however, with the wide fire boxes above the wheels, there is but little excuse for reproducing these cramped water spaces. A free increase in the width of the water space around the fire box increases somewhat the dead weight of the engine, but the advantages to be gained will undoubtedly more than offset this.

I do not know of any experiments which will show the influence of the width of the water space on the evaporation, but it is obvious that a free circulation of the water will be ensured by wide water legs and will help the evaporative power of the fire-box heating surface. In addition to the size of the water spaces, their shape has considerable influence on the evaporation and life of the fire box.

As the water in contact with the side sheets is turned into steam it must be allowed to rise to the steam space and must be replaced by other waters. The water spaces should be so designed that this natural circulation is aided, and that the currents of steam and water impede each other as little as possible. This is secured if the fire-box side sheets are vertical or with a slight slope outward as they rise from the mud ring, so that the steam can rise along the fire-box sheets and the water descend along the outside steel sheets without mutual interference.

If, on the other hand, the fire-box sheets slope inward in rising from the mud ring, the steam will tend to rise from the side sheets through the water space and along the outer sheets to the surface, thus interfering with the descending water current.

The side sheets, being subject to the full effect of the fire, require an active supply of water to allow the vigorous evaporation to proceed properly. If the water spaces are cramped or badly arranged, so that the water supply is not kept up, the

water will fail to reach large areas of the side sheets, with results very detrimental to the life of the fire-box sheets and stay bolts.

In one case of this sort we found on a certain lot of locomotives that there was a well-defined oval space on each side sheet in which it was impossible to keep the stay bolts tight until the cause of the trouble was removed by redesigning the water space to give the water free access to the side sheets.

Another advantage obtained by the widening of the water spaces is the increased flexibility and endurance of the stay bolts. Some tests recently made on the Baldwin Locomotive Works vibratory stay-bolt testing machine show the advantage which can be expected from this source. Nine test pieces were cut from the same bar and vibrated with a deflection of 3-32 inch each side of the center while under a load of four thousand pounds. All conditions were the same except the length of the test piece vibrated. Three bars were 8 inches, three 6½ inches and the remaining three were 5 inches in length. The average number of vibrations before fracture was 1,620 for the 8-inch, 960 for the 6½-inch and 695 for the 5-inch bolts. An increase of sixty per cent in the length of the bolt added more than one hundred and thirty per cent to its life when vibrated.

It appears that the rule for the best width of fire-box water space is very much like Mr. Forney's rule for the size of a locomotive boiler, which is, make it as large as the other conditions permit.

THE PRESIDENT: This subject is now open for discussion. We would like to hear from any member. It is a very interesting subject.

MR. GEORGE R. HENDERSON: I would ask Mr. Fry if I understood him correctly that the fire box which is narrow as you rise up from the mud ring interferes with the elimination of steam from the water more than if it bulges outward. That is what I understood him to say, but can hardly think he meant it. I would like to be put straight on that point.

MR. FRY: If the side sheets slope from the mud ring inward the rise of steam coming perpendicularly will have to pass through the descending water on the outside sheets and will interfere with the current going down the outside sheets. If the fire box

slopes outward the steam will go along the fire-box sheets and the water go down clear of the steam.

MR. HENDERSON: It interferes with the bubbles formed above it. The steam will have to force a track through the bubbles. If it slopes together, each bubble will be free to go up without interfering with the others. The outside shell can be straight or any other shape, but I thought you were speaking of the fire box. If the fire-box side slopes inward, all the steam bubbles will be able to go straight up, but if it slopes outward they will not.

MR. FRY: The idea is to make the current of steam rise along the inside fire-box sheet, independently of the water going down the outside sheets.

MR. HENDERSON: That will burn the sheet out.

MR. FRY: Not if you get your water down quickly enough.

MR. HENDERSON: I do not believe you can under the intense heat.

PROF. W. F. M. GOSS: I would ask Mr. Fry whether he assumes that the outside sheet will have the same general contour as the inside sheet.

MR. FRY: That was my idea.

MR. T. H. CURTIS (L. & N.): I kept careful data for three years to see if we could determine whether there was a given mileage for stay bolts. I have found in a certain class of boilers that there was practically a given mileage for the breaking of stay bolts, although if you take a boiler in some other class of engines, that rule would not apply at all. For instance, some boilers would break a large number of stay bolts in the front flue sheet. Other boilers, of a similar class, would not break them in the flue sheet but broke them in the side sheets. I did find that over one-half of all the stay bolts broken were broken in the first four rows adjacent to the cross sheets, or the sheet across the boiler, where the fire box may not expand. I also found that the increase of steam pressure caused an increase in the breakage of stay bolts, but I could not find that the length of the stay bolt made much, if any, difference in the breakage thereof. Some boilers had longer stay bolts than others, in some cases, as long as fourteen inches. I watched these very closely and they

broke more than any others. I found one which broke in two pieces, breaking a piece out in the center. I never saw but one other illustration of a case of that kind. It is my conclusion that that there is some unknown law which applies to these boilers. If we knew it, we could use it to good advantage. I believe the pressure is a large factor in making up this law of broken stay bolts.

MR. J. F. DEEMS (N. Y. C. & H. R.): I think the road with which Mr. Clark is connected has some engines built three or four years ago, in which they use some ¾-inch stay bolts, reducing the size and increasing the number of bolts. It may be of interest to know what the results are, if the engines have been in service long enough to determine the working of these stay bolts.

MR. F. H. CLARK (C. B. & Q.): I am unable to give any information on that subject, except to say that we bought a number of engines with ¾-inch stay bolts spaced three inches apart. I do not think the engines have been in service long enough for us to give any definite information on the subject.

THE PRESIDENT: Can any member bear out the statement made by Mr. Fry about sloping side sheets?

MR. F. M. WHYTE: I think that experience has been had with throat sheets sloping at such an angle that the sheets have been burned out, after they had been a short time in use, thus showing that the water did not get to the sheets to protect them.

MR. J. F. DEEMS: Some years ago I had an experience with some of the first semi-wide fire-box engines which were built, in which we gave both the inner and the outer shell a very decided slope and the result was that the side sheets burned out within, as I now recall it, a matter of five or six months, showing conclusively that what Mr. Fry has said took place — that the bubbles arising from the inner sheet rose vertically and interfered with the circulation of the water going down near the outer sheet, and the result was that the side sheets were burned out very quickly. I think there is no doubt that that will occur. If the outer sheet is made vertically, or a little wider at the top — if that were possible — I believe you would secure better results.

MR. A. E. MITCHELL (L. V. R. R.): The old-fashioned deep boxes, where the fire box was between the frames, was more satisfactory than our present wide fire boxes. We always got better results by having the inner sheet and the outer sheet widen rapidly as they arose to the top of the water space; in other words, we generally made the water space two inches wider at the top of the vertical portion than at the bottom. I have always endeavored, in designing engines, to make the fire-box sheet as near perpendicular as possible. I believe that this is along right lines. I have been very much interested in the discussion on this subject, and I should like to hear it discussed further.

MR. L. M. POMEROY (General Electric Co.): Would the same theory hold good with the Wootten type of fire box?

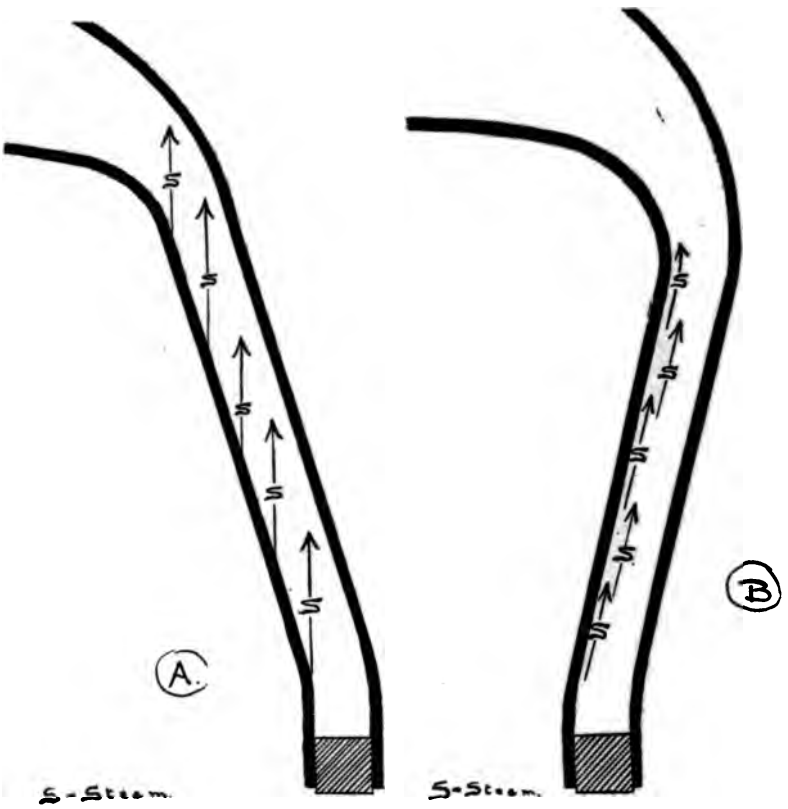
MR. FRY: The increase of the width of the water space is more rapid there and it gives a better chance for the circulation, for the water going down on the outside sheets.

MR. HENDERSON: The inside sheet has a great deal of slope in the Wootten?

MR. FRY: Yes.

MR. HENDERSON: Perhaps I do not get the point — whether Mr. Fry means that the water space, if it has the same width from the mud ring up, should be vertical, or whether he prefers to have the outside wall vertical and the inside wall of the fire box sloping so as to give increased width of water leg as you rise from the mud ring. The Wootten fire box, which Mr. Pomeroy speaks of, increases this width very greatly. The outside shell is nearly straight, and the inside shell has a great deal of slope and increases the water space as you rise from the mud ring.

MR. FRY: The effect I am trying to describe is illustrated by the diagrams. In diagram A the side sheet slopes inward from the mud ring. The steam rises in the vertical lines S S across the water leg, and prevents the formation of any continuous descending current of water. If the evaporation is violent, there is a tendency to blow all the water out of the water leg. In diagram B the side sheets slope outward from the mud ring and the tendency of the steam is to rise along the inner sheet, as shown



by the line S S, giving the colder water a chance to descend rapidly along the outside sheets to take the place of the evaporated water.

MR. HENDERSON: You are referring to parallel water legs or where there are two or three inches larger space at the top? If that is the case, it puts a different aspect on the question and it agrees with my ideas.

MR. T. M. FEELEY (Iowa Central Ry.): This is something that affects every Master Mechanic — every man having charge of the motive power department — the condition of the fire box. I do not know whether the speaker has taken into consideration, in connection with the method of building the sheets, the

importance of arranging the side sheets in connection with the flue sheet to prevent trouble in the fire box from excessive expansion and contraction on account of the heavy pressure carried by the heavy engines in present use. Since the introduction of the heavy power and heavy tonnage trains, the boiler pressure has been increased and our troubles have increased accordingly. I think every Master Mechanic should discuss this subject. This is the first meeting of the Association which I have attended at which the subject has been brought up, and I should like to find out from some of the members what troubles they have, and what method they employ in applying side sheets in fire boxes in order to overcome excessive expansion and contraction, and add to the life of the sheet. We have corrugated fire boxes, and we have the Laughridge fire box, and various other types. There is room for a very general discussion on this subject, and I should like to see the matter taken up in that way.

MR. W. H. V. ROSING (Missouri Pacific Ry.): I believe that the narrowest part of the fire box should be at the mud ring. The difficulty with cracked side sheets and broken stay bolts is largely due to the absence of water during certain intervals along the side sheets. I do not believe that the water circulates from the crown sheet downward in the side legs of the fire box. I think the vertical cross section of the side water leg should be widest at the flue sheet, to permit the water from the shell of the boiler to circulate backward through the side water leg. The engines which we last designed had fire boxes narrower at the mud ring than at the crown sheet. Since little or no trouble is had with crown sheets cracking on account of their being covered with water, it is my opinion that the side sheets which crack do so because water is not always in contact with the sheet.

MR. W. E. SYMONS (K. C. So.): Mr. Fry's paper and discussion thereon has brought out a number of very good points. I am inclined to the belief, however, that while we may, as the result of this discussion, be able to arrive at what might be termed a happy medium to adopt as good practice in construction of boilers, that it is largely a matter of local conditions. The behavior of different waters is entirely different. Some loco-

motives with certain size boiler will give good results in one district and when transferred to another will give very poor results — directly the reverse. I have known of side sheets having to be removed within the period of time mentioned by Mr. Deems, in certain districts, while in other districts they would last two or three times as long.

I have had experience on steamships equipped with different types of boilers. On entering certain harbors, one of the boilers would behave badly, so that it would be almost impossible to operate it, while the other boiler would give no trouble at all, showing it was the water condition. I have observed similar results, at various times, in operating locomotives, and am inclined to believe that as the result of our deliberations we can arrive at what might be termed the best practicable boiler for general use. At the same time I think it is largely a matter of local conditions to be determined upon after thorough experiment with the character of water used, steam pressure carried, size of boilers, service required, etc.

PROF. W. F. M. GOSS: I want to add my approval of certain principles which are laid down by Mr. Fry. We will all agree, I think, that we are not likely to get the water space too wide at the mud ring. As a matter of principle, the wider it is the better. There should be no contraction of the water space above the mud ring, but on the contrary it should widen out. The observance of these principles makes the whole problem one which is quite as closely related to the form of the outside sheet as to that of the inside sheet. The form of the outside sheet must be established with reference to external conditions, and when this is done, the inside sheet should be shaped entirely with reference to the water space.

Concerning the remarks of the last speaker, in which attention is called to the influence of a local condition, I would add that while the difficulties which appear in the operation of a locomotive boiler are, as stated, greatly affected by local conditions, yet a boiler which is designed right for conditions which are severe, will never give trouble under conditions which are more favorable. So that the question of design remains to be established as a matter of principle, and is not greatly dependent, it seems to

me, upon local conditions. A design which is correct, should be expected to give best results under all the various conditions of service with which such boilers have to contend.

MR. C. A. SELEY (C. R. I. & P.): The power committee on the Rock Island last year determined to adopt 4½ inches as the standard of width of mud rings. The question of 5 inches was also considered, but it introduces certain difficulties in the forging of the ring and in the riveting. I believe that 4½ inches, which is a considerable increase on present general practice, will largely minimize the breakage of stay bolts.

MR. J. F. WALSH (C. & O.): Diverting for a moment from the subject of stay bolts, and still continuing in line with the subject of fire boxes, I wish to say it has been our experience in using the wide fire box that if, for any cause, we had to remove the arch pipes and leave them out of any particular engine, that in a short time we find the fire box of that engine becomes troublesome, and upon replacing the arch pipes we always find that there are very few leaky fire boxes. I give you that for what it is worth. Our experience has been that the arch pipe itself is a very decided gain in preventing leaky fire boxes in the wide fire box.

MR. A. E. MITCHELL: I would ask if in adopting the 4½ inches as the width of the mud ring, if that covered the throat sheet as well?

MR. C. A. SELEY: It was 4½ inches all around.

MR. E. N. WIEST (M. & N. E. R. R.): I may be able to throw a little light upon this subject about the inside sheet of a fire box not having water come in contact with it.

A few years ago, in considering the question, we were inclined to believe that where the engine was working hard and the boiler evaporating water most rapidly, that owing to the narrow water space around the fire box, the volume of steam accumulating next the inside sheet would be sufficient to prevent the water from coming in contact with it.

In experimenting, I made a connection in the outside sheet, two feet above the grates of a deep fire box, having three and one-half inches of water space, and ran a pipe to within one-half

inch of inside sheet. I made careful tests under all conditions, and was never able to get clear steam out of the pipe, thus proving that at all times water was coming in contact with the sheets.

I have found from my observations that it was more a matter of what the plates were made of than it was of not getting water against the sheets.

THE PRESIDENT: If there are no further remarks on this subject, we will ask Mr. Fry to close the discussion.

MR. FRY: I do not think I have anything further to say on this subject.

THE SECRETARY: The next topic is "Locomotive Stokers." This was to have been opened by Mr. William Garstang. I received a telegram from Mr. Garstang last night, saying that he had mailed his topical discussion on the mechanical stokers. The discussion has not yet arrived. Mr. Garstang will not be able to be here until Saturday evening. I would suggest that we postpone the discussion until Friday, and in the meantime take up the individual paper on "The Value of Superheated Steam for Locomotive Work," by Mr. H. H. Vaughan, of the Canadian Pacific Railway.

THE PRESIDENT: If there be no objections, we will proceed to the consideration of the paper by Mr. Vaughan.

Mr. Vaughan then presented the paper, which is as follows:

AN INDIVIDUAL PAPER ON THE USE OF SUPERHEATED STEAM ON LOCOMOTIVES.

I. HISTORY.

The use of superheated steam has rather a peculiar history; unlike the turbine, which lay neglected, with its possibilities unknown, through the years in which the reciprocating engine gradually attained its present state of perfection, superheating was employed and proved its value when the steam engine had already left the experimental stage, when reliable operation had become established, and economy was regarded as a matter of importance. After demonstrating the advantages that could be gained by its use, it was gradually abandoned by the large majority of engineers, and not again resorted to until successive stages of increasing pressure, ordinary multiple compounding, jacketing and refined designing, had been brought to their greatest perfection. When its reintroduction took place, its progress was slow, and years were required to obtain its recogni-

tion as a necessity in every plant where power is to be obtained with the greatest economy.

The earliest recorded attempt at superheating was that reported in 1828 by Richard Trevithick, at the Birnie Downs Mine in Cornwall, on a condensing pumping engine making eight strokes per minute, with a boiler pressure of forty-five pounds, in which the cylinders and steam pipes were surrounded with brickwork and heated from a fire burning on a grate underneath. The results were remarkable, for, while performing the same amount of work, 9,000 pounds of coal were used per twenty-four hours without the fire under the cylinder, against 6,000 pounds when it was in use, the coal for superheating included. This experience led Trevithick to the invention of his tubular boiler and superheater, which was patented in 1832, and was a remarkably modern-looking arrangement, the boiler proper consisting of vertical water tubes surrounding a circular grate and forming a vertical flue in which other tubes were placed, through which the steam, generated in the boiler, passed on its way to the engine. Owing, no doubt, to the difficulty in regulating the temperature of the steam obtained from such an apparatus, little seems to have been done in the matter during the next ten or fifteen years, although in 1832, I. Howard, of Bermondsey, produced a superheater which obtained an economy of 30 per cent, and about 1835, Dr. Haycroft, of Greenwich, advocated superheated steam and found, experimentally, about the same saving.

From 1850 to 1865 the interest in this subject revived considerably, and a moderate degree of superheat was quite extensively employed toward the latter part of that period. Hirn, in 1857, published the results of experiments made by him at Colmar, which were the most carefully conducted tests that had, up to that time, been carried out, and showed that, on a simple engine, working with a boiler pressure of fifty-five pounds, economies of 20 to 47 per cent could be obtained with superheat of 100° to 190° F. In 1859, John Penn read a paper before the Institution of Mechanical Engineers describing several applications to steamships, the superheater consisting of a number of tubes about 2 inches diameter placed in the uptake just as it left the boiler, through which the steam passed on its way to the engine. The superheating surface was about 15 per cent of the boiler heating surface, and with a boiler pressure of twenty pounds on a condensing engine, about 20 per cent saving on fuel was obtained with a superheat of 100° F. John Ryder, in 1860, in a paper before the same society described the Parson & Pilgrim superheater, which consisted of two horseshoe-shaped pipes placed in the internal flue of the boiler over the fire grate, and the Partridge, which was a cylinder filled with tubes through which the gases passed, the steam being around them. Both of these systems were stated to have given good results, which may appear rather questionable in the case of the former, but a total of 5,000 horse-power had then been equipped. The superheating surface employed was 2½ to 2¾ square feet per nominal horse-power, or

about the same as that described by Penn, and the economies obtained were practically equal.

Sundry other systems were in more or less extensive use about this time, such as the Crossland, Wethered, etc., and extensive experiments were carried out by Isherwood, in the American Navy, which confirmed the good results obtained abroad.

While a large amount of evidence was thus created in favor of superheating, and it was employed to a considerable extent, placing it beyond the experimental stage, it gradually gave way before the development of increased boiler pressure and compounding, which commenced about 1865. When boiler pressures were from twenty to forty pounds, superheaters in the uptakes, which gave 100° to 125° of superheats, could be employed without exceeding a temperature in the cylinder at which the animal lubricants used in those days would decompose and attack the valve faces and cylinder bores, but as the pressure was increased, the same amount of superheat could not be used. The absence of moisture in the superheated steam made lubrication necessary, and the packings used on valve stems and piston rods were also badly adapted for steam at high temperatures and gave considerable trouble when 350° was exceeded. Trouble was also experienced in the superheater tubes, caused by deposits of salt on account of the use of the jet condenser, which was then universal. By employing a higher boiler pressure and avoiding cylinder loss by compounding, the same economy could be obtained as by superheating with a decrease in trouble, and its use gradually declined until about 1870 it was rarely employed on new work, excepting by the Alsatian group of engineers, by whom it was never abandoned. With the introduction of hydrocarbon lubricating oils, balanced valves and improved packing, the use of considerably higher temperatures became possible, and in 1890, interest in this subject was renewed by the attention drawn to the results being accomplished in Germany by such engineers as Gehre, Schwoerrer, Uhler and others. Many results were published, all of which showed a gain from the practice, and in England, in addition to the introduction of their apparatus, several other types were developed along similar lines. Since that date the progress of superheating in stationary practice has been comparatively steady, although slow, and it has in general developed along the lines of moderate superheat, say from 50° to 100°, no special type of engine or boiler being usually employed, and its subsequent history, with one notable exception, concerns stationary and marine practice rather than locomotive. That exception is the use of highly superheated steam, perfected after fourteen years' experimenting by Mr. Wilhelm Schmidt, of Cassel, who succeeded about 1894 in producing a boiler and motor in which steam, superheated to 700°, was used at comparatively low pressures. The results obtained were reported by Messrs. Schneider and De Grahl in 1894, and were exceedingly economical, especially on small engines, and in 1898, two hundred plants were reported to be working on the Schmidt system; but apart from these, highly superheated steam

can hardly be said to have come into general use. In view of the present applications of superheated steam to locomotives, the general lines of its introduction into stationary and marine practice are interesting. Moderate superheating, employing temperatures up to 150° above that of evaporation, first scientifically investigated by Hirn, introduced extensively into early English marine practice by Penn and others and then abandoned; continued in stationary practice in Alsace by Hirn's pupils and followers, has, in the last ten or fifteen years, become extensively used in stationary practice with increasing steam pressures. High superheating, developed by Schmidt, has been economical and satisfactory where employed, but so far, is not in general use.

Superheated steam is supposed to have been first applied to locomotives on the Chicago, Burlington & Quincy Railway in 1870, the front tube sheet being set back some distance into the boiler, and the superheater, consisting of a separate cylinder in which the tubes formed practically a continuation of the boiler tubes and into which the steam entered by the dry pipe, and from it passed to the cylinders by pipes connected to the bottom. Such an apparatus could not have actually superheated the steam to any great extent, but it showed some economy which was not, however, considered sufficient to pay for its increase in cost and the trouble of maintaining it, and it was subsequently abandoned. The present development in the application of superheated steam to locomotives is due to Messrs. Garbe and Muller, of the Prussian State Railways, who in 1898, arranged to equip two engines, Hanover No. 74, built by the Vulcan Company, of Stettin, and Cassel No. 131, built by Henshel & Co., the design being prepared by Mr. Schmidt. In a paper read by Mr. Garbe in 1902, before the Berlin branch of the Institution of German Engineers, he related the various reasons that led him to a consideration of the advantages of superheated steam, and discussed in a comprehensive way the benefits derived from its use and the results at that time obtained. This paper is of special interest, as it describes the first modern application of superheated steam to a locomotive, and shows it to have been a decided success. These engines were followed by others, for which Mr. Schmidt designed what is now known as his smoke-box type of superheater, and in 1899 one engine was put into service with this device. It was followed in 1900 by three others, and in 1902 by twenty-four, thirteen of the latter being eight-coupled freight engines, until by the end of 1904 the Prussian State Railways had put into service one hundred and twenty-seven engines using superheated steam, all except the original two and the last one having the smoke-box type of superheater. Other European roads have, since 1902, also built engines with the Schmidt designs of superheaters, the smoke-box and smoke-tube types being used about equally, and in all about one hundred and seventy of these engines are in service. Other engines have also been equipped with the Pielock, a rather different type of superheater to the Schmidt, which was developed in 1902, and which has now be applied to about thirty locomotives, thirteen of these being on t

sian State Railways, so that, in all, fully two hundred engines in Germany are now running with superheated steam. In America it was introduced by Mr. Roger Atkinson, then mechanical superintendent of the Canadian Pacific Railway, who, in 1901, applied a Schmidt smoke-box superheater to an 18 by 24 inch ten-wheel simple freight engine with 62-inch wheels. This engine proved exceedingly satisfactory, and was followed two years later by two ten-wheel compound freight engines, which were equipped with the Schmidt smoke-tube arrangement. All these engines showed a substantial economy over similar engines of the ordinary type, and, in 1904, forty-one simple consolidation engines were built, of which twenty were equipped with the Schmidt and twenty-one with the Schenectady superheater. During that year one of the latter type was also applied to an Atlantic type simple engine on the New York Central and to a ten-wheel passenger engine on the Canadian Pacific. During the present year, 1905, the Canadian Pacific Railway is building fifty-five simple ten-wheel freight engines and six Pacific type passenger engines, which will be equipped partly with the Schmidt and partly with modified Schenectady and other types of smoke-tube superheaters, and a number of other roads are also experimenting with this system, which is therefore fairly well started, experimentally, and is now in sufficiently extensive use to develop its troubles in regular service, and emerge from the nursing stage, which always engenders the suspicion that particular attention to one engine's performance may obtain results that would not be realized from a number.

II. THEORY.

The theoretical considerations involved in the use of superheated steam have been discussed so thoroughly in various papers and text-books on the subject that any extended treatment of them in this article is superfluous. It is necessary, however, to note certain facts in connection with this question on account of their bearing on the results that have been obtained and the designs of superheaters that are at present in use, and there are, besides, certain conditions in locomotive work which render some results important that do not generally apply in stationary practice.

When water is converted into steam, its temperature depends upon the pressure at which it is evaporated, and in steam, as it is commonly used in the saturated state, these quantities are absolutely dependent, to the extent that any further addition of heat to the boiler does not result in an increase in the temperature of the steam, but simply increases the amount of water evaporated, and conversely any abstraction of heat from the steam will immediately condense a portion of it. If, however, the steam, after being evaporated, is still further heated, it becomes superheated, and its volume increases in proportion to its rise in temperature. It is possible to heat steam in such a way that the volume remains constant and the pressure increases with the temperature, but this method can not be carried out in a superheater, as the pressure is governed by

the boiler with which the superheater is necessarily in communication, and consequently remains constant. The amount of heat required to raise the temperature of one pound of steam one degree under this condition, is the specific heat of steam at constant pressure and is not accurately known, although commonly stated to be 0.48, as determined by Regnault. More recent experimenters have, however, assigned to it a higher value, and in an article in *Power* for August, 1904, G. A. Orrok analyzed the experiments of Gruilly, Greissman and others and showed that it probably varies with the pressure, and that its instantaneous value equals $0.00222t° - 0.116$, where t° is the temperature Fahrenheit. This corresponds to a value of 0.65 at 350° and 1.0 at 500°, and is slightly higher than the latest determination by Mr. Jakeman, of the British National Physical Laboratory, who found it to be 0.59 between 290° and 420° at sixty pounds pressure, so that, allowing for a possible increase in the last figure with the temperature, a value of 0.7 may be assumed in connection with locomotive problems, and this figure will be used in this paper where not otherwise noted.

When superheated, steam behaves to a certain extent like a gas, its equation being $P\ V = 0.5927 6t°$, where P is the absolute pressure in pounds per square inch, V the volume of one pound in cubic feet, and t° the absolute temperature Fahrenheit, the constant being that derived by Schmidt. At constant pressure the volume thus varies directly as the absolute temperature, limited, of course, by the latter not being lowered below that of saturated steam at the same pressure, as in that case the superheat would disappear and the steam would commence to condense. The temperature can, however, be increased to any desired extent, with a corresponding increase in volume, but without change in pressure, and this leads to two advantages, the possibility of obtaining a working fluid, which can be cooled without immediate condensation, and one which may be used at high temperatures without excessive pressure.

The first of these is of considerable importance, and is the cause of the greater part of the economy obtained by superheating. In the case of an engine using saturated steam, no heat can be abstracted from the steam to warm up the cylinder walls or steam passages without a sufficient amount of steam being condensed to furnish, by its latent heat of condensation, the heat required. This condensed steam is deposited over the entire surface in a finely divided state, and the larger portion of it remains as water until exhaust takes place, when, owing to the comparatively low temperature at which water is converted into steam at exhaust pressure, it is reëvaporated by absorbing heat from the cylinder walls, which by that time have attained a higher temperature than the exhaust steam. In the process of evaporation the water abstracts heat very readily on account of its close contact with the metal, and while being evaporated it can absorb a large amount of heat without its temperature being raised, about 950 B. T. U. for each pound converted into steam. In the case of an engine using a gas, where no condensation takes place, this interchange of heat is limited to a reduction of temperature during admission, and an

increase of temperature during exhaust, of the gases in immediate contact with the walls, and since the heat required to raise or lower the temperature of a gas considerably is very small, the heat abstracted from the cylinder walls during exhaust is correspondingly less. Were one pound of gas the amount affected by this action, it would only require fifty B. T. U. to raise its temperature 100°, showing the vastly greater capacity of a film or scattered drops of water to change the temperature of the metal with which it is in contact. The evaporation during exhaust of the water condensed on the walls during admission is the means by which their temperature is lowered, and by avoiding its condensation, their variation in temperature is greatly decreased. Superheated steam, having a temperature higher that that corresponding to its point of condensation under any given pressure, can part with a portion of its heat to the cylinder walls without being condensed, and will, if the superheat be sufficient, avoid it entirely, thus approximating the condition of an engine working with a non-condensable gas.

In an engine operating with saturated steam, there is, in addition to that shown on the indicator diagram as present in the cylinder, a quantity of steam passing into the cylinder at each stroke, which condenses into water during admission and is reëvaporated during exhaust without performing any useful work; while, if sufficient superheat is employed to render the steam dry at cut-off, all the steam that has passed into the cylinder is that shown on the diagram, the heat absorbed by the cylinder walls being furnished by its drop in temperature in place of by condensation.

The question is treated with great clearness in the "Steam Engine, Theory and Practice," by William Ripper, and some results from a small Schmidt engine, for which figures are given, exhibit the action that takes place very well. It was found that for each 1 per cent of wetness or steam condensed at cut-off when working with saturated steam, it required 7.5° of superheat in the entering steam to prevent any condensation up to that point. Thus in case 25 per cent of the steam was condensed at the point of cut-off, in order for it to be dry at that stage, 7.5×25 or 187.5° of superheat would be required. Supposing then it takes one pound of steam to fill the cylinder at cut-off, which would require for its production about 1,000 B. T. U., in the first case, since 25 per cent of condensation took place, a total of 1 1-3 pounds was admitted, to produce which takes 1,333 B. T. U.; in the second case, in addition to the 1,000 B. T. U. to produce the steam, sufficient heat must be added to superheat it 187.5°, and as Professor Ripper takes 0.48 as the specific heat of superheated steam, this requires ninety B. T. U. additional. Since the work performed is practically the same in both cases, the heat required is thus 1,333 B. T. U. in the first case, and 1,090 in the second, or a gain of 22.3 per cent, and while these figures do not, of course, apply to every engine, they illustrate the reason for the economy that is obtained through the decrease in the amount of heat interchanged with the cylinder walls, which may be termed

the economy due to temperature, as it is caused by the steam being at a sufficiently high temperature to prevent its being cooled without immediate condensation. In Professor Ripper's work, diagrams are given which are reproduced in Fig. 1, which show this interchange of heat, in the case of saturated, medium superheated, and high superheated steam respectively, and since this heat may be taken as wasted, they are interesting as showing the loss that is avoided. The shaded areas, showing the heat interchange, are drawn to the same scale as the indicator diagrams, so that their area shows the wasted work on this account in comparison with the useful work shown by the indicator diagram.

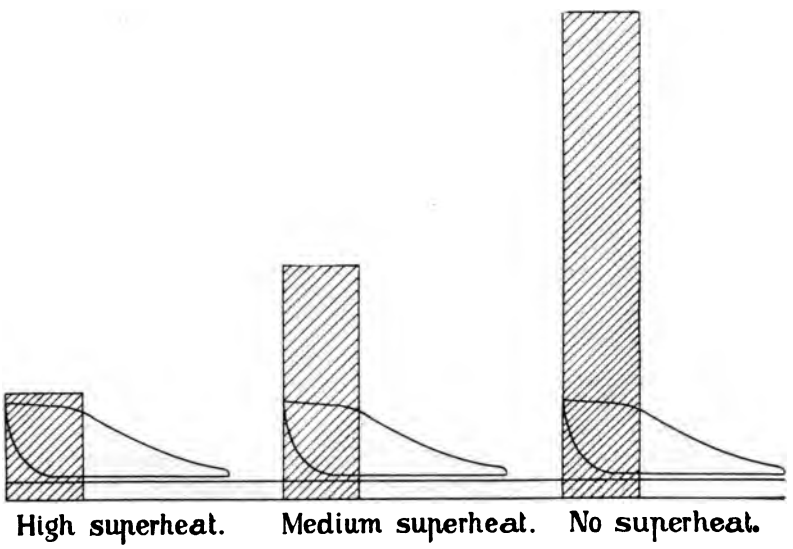


Fig. 1.

When steam is superheated beyond the point at which dry steam is present at cut-off, a still further gain occurs on account of decreased heat interchange up to the point where it is dry at release, which requires an increase in the superheat of from 50° to 100°, according to the rate of expansion and other conditions, and in stationary practice, where an economical rate of expansion is invariably employed, superheating is rarely carried to this point. In locomotive work, however, engines are commonly worked at long cut-offs for considerable distances, and in such cases it is exceedingly likely, when the steam is considerably superheated, that superheat may occur at release. This is not a loss, as commonly stated, but is a gain due to the second advantage mentioned, that of a

working fluid which may be used at high temperatures without excessive pressure.

The amount of work that can be performed by one pound of steam, whether used expansively or not, is very closely proportional to its P V, or absolute pressure multiplied by the volume of one pound of steam at that pressure, and since the amount of heat required to produce one pound of steam varies with its pressure and temperature, the P V divided by the heat of production is a measure of the economy with which work is obtained. In the case of saturated steam at one hundred pounds (abs) this quantity is 0.372; for saturated steam at two hundred pounds it is 0.383, and this improvement of 2.8 per cent represents the gain in economy due to increasing pressure. Steam at two hundred pounds is slightly more economical than steam at one hundred pounds superheated to the temperature of saturated steam at two hundred pounds, but as the pressure increases beyond that point the gain is very slight, as it depends largely on the temperature, and in increasing the pressure from one hundred to two hundred pounds, the temperature has only increased from 327° to 381°, and there is no practicable increase in pressure that would give any appreciably higher temperature, as at three hundred pounds the temperature is only 420°. By superheating, the temperature, and consequently the volume, can be increased considerably without increasing the pressure; thus, for steam at two hundred pounds (abs) superheated 200°, the P V divided by heat of production is 0.425, a gain of nearly 11 per cent by superheating. This gain, which may be termed the economy due to volume, as contrasted with the economy due to temperature, which acts through the reduction of cylinder condensation, is evidently most effective when steam is used non-expansively or at long cut-off, whereas, the avoidance of waste in the cylinders is not important under those conditions, but operates when the rate of expansion is greater, and considerable loss would occur in an engine using saturated steam. The economy due to volume is obtained through the increase in the volume of steam when superheated, which enables a given weight of steam to provide the volume required for a greater number of strokes of the engine, and it is evident that the economy from this cause commences when the steam is dry at cut-off, and continues when superheat is present at release. It is true that there is a loss in the latter case compared with the result that could be obtained if the steam were expanded to saturation, but it is a loss of the same nature as that occurring when steam at two hundred pounds is released without expansion — a loss occurs, but it is still more economical to use steam at two hundred pounds without expansion than to use steam at one hundred pounds under the same conditions. In locomotive work the pressure is decided on from practical reasons, and the cut-off adjusted to perform the work required from the engine, and in such a case, if superheat occurs at release, there is a gain, not a loss, compared with an engine working under the same conditions, but without superheat at release. This question, which is of some importance, can be decided

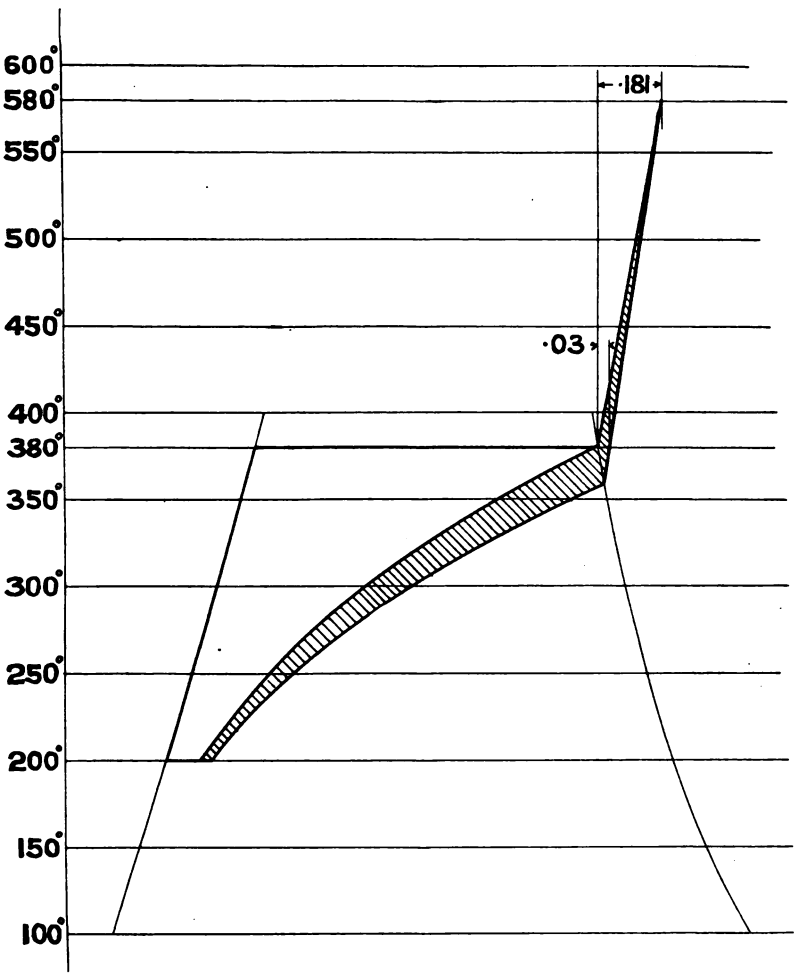


Fig. 2.

by the temperature entropy diagram, and Fig. 2 shows a diagram for steam at 380° working without condensation, non-expansively, with and without 200° of superheat, the shaded areas showing the work due

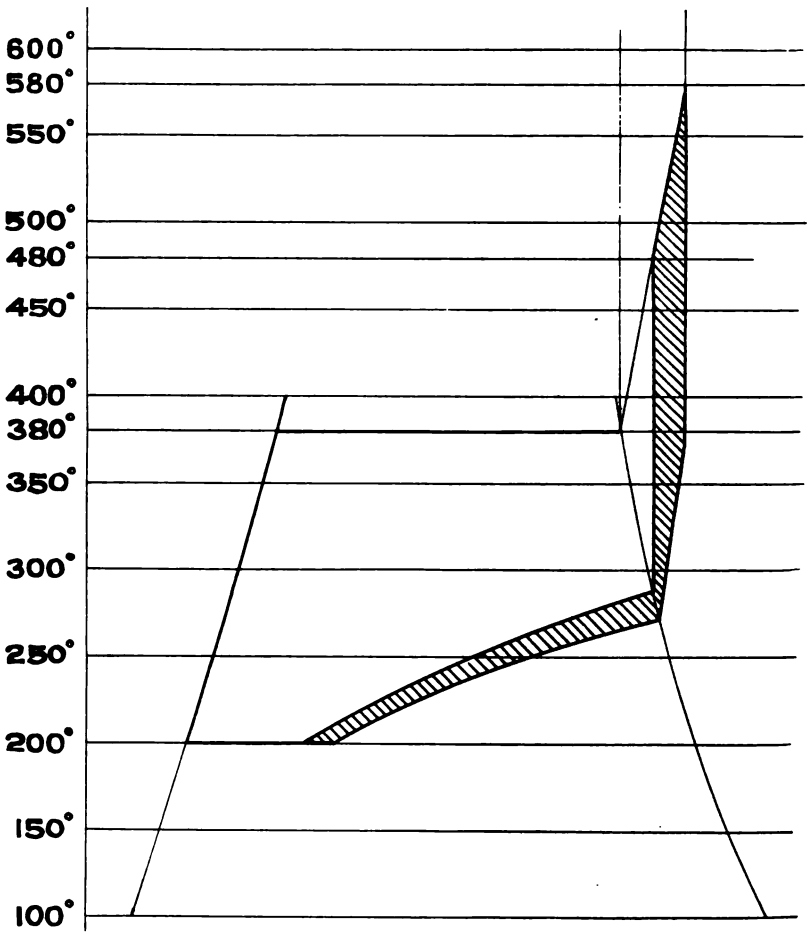


Fig. 3.

to superheating. Fig. 3 shows steam at 380°, superheated 100°, adiabatically expanded until dry at release, also when superheated 200° with the same rate of expansion, and correspondingly superheated at release, the

shaded area showing the work done in the two cases. The thermal efficiencies have very kindly been worked out by Prof. R. J. Durley, of McGill University, and are 0.0754, 0.0825, 0.1332 and 0.1386 respectively, thus showing a gain in the first case of 9.4 per cent and in the second of 4 per cent due to the superheating. Consideration will show that the change in the location of the constant volume line is responsible for the increase and this is caused by the greater volume of superheated steam.

The conclusions to be drawn from these results are that, in locomotive work, should conditions be such that superheat occurs at the exhaust, no loss, but, on the contrary, a gain, is obtained; that this gain, while very valuable at long cut-offs, becomes of less importance as the cut-off is shortened, and a more important economy is then obtained through the avoidance of cylinder condensation. Since the economy obtained from volume is only 10 per cent, with a superheat of 200°, under favorable conditions, while that obtained from temperature may amount to 25 to 30 per cent, the latter is by far the most important, and while economies may be obtained at long cut-offs, the greatest will occur with expansive working. The degree of superheat is not limited by theoretical considerations of cylinder economy, but the gain obtained would be comparatively less when carried beyond the point where the steam is dry at short cut-offs, and such a condition would require about 200° to 250° of superheat in the steam chest. Up to that point, from the point of view of engine efficiency, it is advantageous to obtain as high a degree of superheat as possible.

In the use of superheated steam in locomotives, a knowledge of its action in the cylinders is more important to explain the results obtained than useful in improving them, but its production in the boiler will require careful consideration in the future. It does not follow that because a certain degree of superheat results in a saving of the water required per horsepower hour, that there is a corresponding economy in fuel, in fact, it is invariably less than that in water, and it is quite possible that the consumption of coal may be increased to a point that neutralizes the economy in the consumption of steam. This may be illustrated by the foliowing table, compiled by Mr. Strahl, of the Prussian State Railways, in which a constant volume of steam is assumed per unit of work and the efficiency of the boiler or the B. T. U. transmitted to the steam to the pound of coal is taken as constant:

Superheat, Degrees F.	Economy per cent—Water.	Coal.
18	2.5	2
36	5	3.5
54	8	5
72	10	7
90	12.5	9
108	14.5	10
126	16	12
144	18.5	13
162	20.5	14.5
180	22	16
198	24	17
288	34	24

A simple way of estimating relative engine and boiler efficiencies is to allow 1-20 of 1 per cent decrease in the water evaporated for each degree of superheat, which is very closely correct for a feed-water temperature 62° and allowing 0.7 as the specific heat of superheated steam. In other words, if any boiler evaporates 100 pounds of water into saturated steam with a given amount of coal, it will evaporate 5 per cent less, or 95 pounds, into steam with 100° superheat, and 10 per cent less, or 90 pounds, with 200° superheat. The exact figures at 150 pounds boiler pressure are 94.34 and 89.30 pounds respectively, and at 235 pounds pressure 94.39 and 89.35 pounds, so that in view of the uncertainty of the specific value of the heat, these rough figures are as accurate as any that can be employed. The foregoing table is favorable to the boiler and, therefore, the coal economy, as it assumes that heat is transmitted as readily to the superheated steam as to the water, which is hardly reasonable in view of the higher temperature of the former. Where high superheat is concerned, this difference is quite considerable, and the amount of heat to be transmitted is important. The temperature of the feed-water in a locomotive may be taken at 62°, and at the pressures to be considered — 150 to 200 pounds — the heat of evaporation from that temperature is about 1,160; with a specific heat of 0.70, the heat to be added to the steam increases about .06 per cent for each degree of superheat, and is 6 per cent for 100° of superheat, 12 per cent for 200°, and so on. This heat is also transmitted to the steam at an average temperature higher than that of evaporation by 50 per cent of the temperature of the superheat, and there must evidently be a sufficient difference of temperature at one portion of the superheater to transmit heat to steam that is 100° or 200° above the temperature of evaporation, as the case may be. In locomotives, the only designs of superheaters that have been so far considered practicable, or are likely to be, are those in which the superheating is accomplished by the flue gases, those types developed in stationary practice which employ separately fired superheaters, or tubes placed above

the fire, being evidently impracticable, and these may be divided into two types — those in which a portion of the number of flues is utilized for superheating, and those in which a portion of the length of the flues is used for that purpose. The action of the flue gases in these two types may be illustrated diagrammatically as follows:

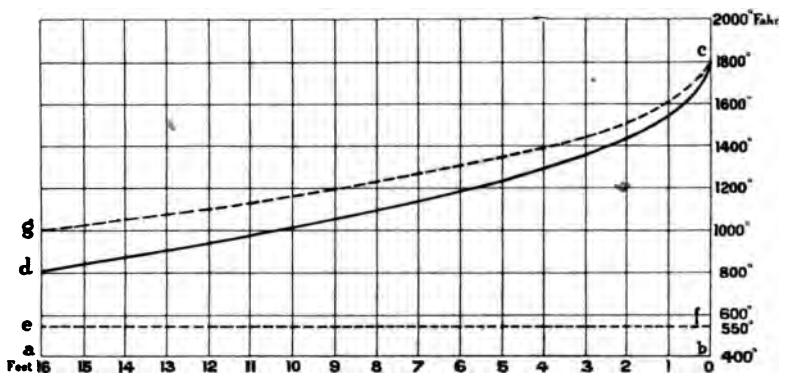


Fig. 4.

In Fig. 4, a, b represents the temperature of the water or saturated steam throughout the length of the flues, c the temperature of the gases entering the flues, and d the temperature leaving the steam flues; e, f represents the average temperature of the superheated steam, and g the temperature of the gases leaving the superheater tubes, which is corre-

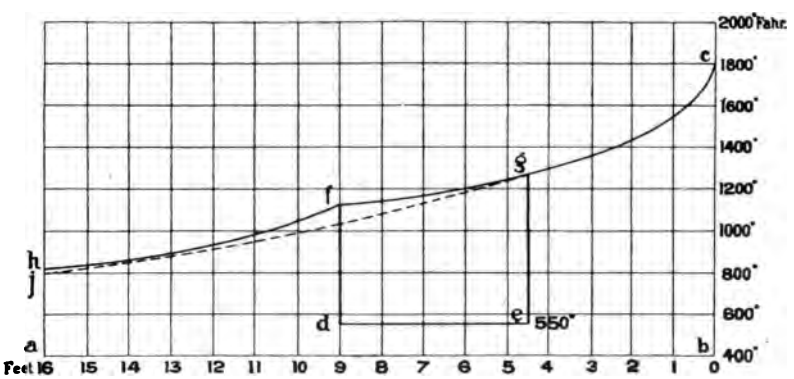


Fig. 5.

spondingly higher than d. In Fig. 5, a, b, c correspond to Fig. 4, d, e represents the temperature and length of the portion of the flues acting as a superheater, and f, g the temperature of the gases at those points; h represents the temperature of the gases leaving the flues, and g, j the temperature in a boiler without superheater. It is evident, in Fig. 4, that unless sufficient superheating surface is obtained to make the difference between g and e less than that from d to a, that percentage of the gases entering the superheater tubes will leave them at a higher temperature than those leaving the steam flues, while in Fig. 5, all the gases leave the tubes at a slightly higher temperature, and this increased temperature of all or part of the gases represents a loss in boiler efficiency. No tests are so far available from which this loss can be quantitatively determined, as it is not only necessary to know the temperature of the gases leaving the tubes, but their amount. The nature of the loss, however, can be estimated from other data for an assumed case, and is of interest as showing its possible extent. An examination of some of the results recently obtained at St. Louis would appear to show that the proportion of the work done in the fire-box is not constant, but is greater at low rates of steaming and is dependent on the brightness of the fire, but that for an average example it may be taken at 40 per cent of the total. The drop in temperature of the flue gases may be taken at 1,000°, say 1,800° on entering and 800° on leaving the flues; this drop is obtained when the flues are maintained at a temperature of about 380°. If the flues were surrounded or filled with superheated steam at an average temperature of 100° higher, the gases would be lowered to 900° in place of 800°, or there would be a drop of 900° in place of 1,000°. Since for 200° superheat the amount of heat to be added is 12 per cent or 10.7 per cent of the total, and this is all obtained from the flue gases at an efficiency of 9-10, as compared with that required for evaporation, 10-9 of 10.7 or 12 per cent of the total heat must pass through the superheater tubes, and as 12 per cent of the total equals 12-60 or 20 per cent of the heat developed in the flues, 20 per cent of the flue gases will be released with a drop in temperature of 900° in place of 1,000° or with a loss of 10 per cent. If therefore, without superheating, the heat transmitted was equal to 40 units in the fire-box, and 60 in the flues, then in this case, 40 would be delivered in the fire-box, 48 in the water tubes, and 9-10 of 12 or 10.8 per cent in the superheater tubes, a total of 98.2 or a loss of 1.8 per cent. This is evidently not of great importance, but in certain designs of superheaters it is possible to pass a considerable portion of the gases through the superheater tubes, and in one engine experimented with on the Canadian Pacific Railway, an improvement was obtained by reducing the proportion of gases passing to the superheater, showing that the possible loss on this account merits attention. It is evident that in place of the gases leaving the superheater at a temperature 100° higher than those leaving the water tubes, they were 200° or 300° above them, the loss would be 3.6 per cent or 5.4 per cent under the above conditions, and

in such a case would become serious. The second type of superheater has evidently a slight advantage over the first in this respect, as the gases, passing through the water tubes after leaving the superheater, are reduced to practically the same temperature as those in an ordinary boiler, but sufficient has been said to deduce the conclusion that, while, with proper care in the design and adjustment, either of these types may be substantially as efficient as an ordinary boiler, that superheaters of the first type are susceptible to loss which may be serious, but which is necessarily minimized in the second. The first type has, however, an advantage in the ease with which a considerable degree of superheat can be obtained, as any desired proportion of the flue gases can be diverted through the superheater, whereas, the second is more limited in this respect, since the distance from the fire-box at which it can be placed is limited for practical reasons, and the amount of superheating surface is restricted at the same time. An inspection of the diagrams will show that, considering the large percentage of the heat in the flue gases that must be used for superheating, and the high temperature at which they must be brought in contact with the superheating surface, if the latter is not to be excessive, that any consideration of superheating in the front end must be abandoned, as the flue gases at that point have too nearly the required temperature of the superheated steam to allow them to transmit heat very readily, therefore, one of the two types mentioned or some combination of them must be employed. In view of the present small amount of accurate knowledge on this question, it is hardly worth while to further investigate it theoretically, as the value of the specific heat, the dryness of the steam entering the superheater, its rate of flow, and other factors complicate it to a point where accurate calculation is impossible. This question was carefully gone into by Mr. Otto Berner in a paper republished in the Bulletin of the Railway Congress in February, 1904, but it can hardly be said that the deductions are decisive on account of our indefinite knowledge of the various factors involved. It may be stated, however, that as the degree of superheat is increased, the water evaporated per pound of coal will decrease, not only on account of the additional heat contained in each pound of steam, but also on account of the decrease in the boiler efficiency due to the higher temperature of the steam to which the heat must be transmitted. This loss in efficiency will, of course, counteract to a certain extent the advantages gained in the cylinder and will reduce the gain from superheating beyond a certain amount. While the actual quantities are not at present known, this may be illustrated diagrammatically in a way that explains the results that are to be looked for. Fig. 6 shows the general form this diagram takes, the ordinates being per cent of reduction in B. T. U. required per unit of work, or the pounds of steam per horse-power hour, corrected for the increase in the amount of heat per pound of steam on account of being superheated, and the abscissæ being the degrees of superheat. The line a, b, c shows the gain due to temperature or to the avoidance of cylinder condensation at 90 per cent cut-off, taken

at 5 per cent, the line b, d showing the further gain due to volume, by further superheat, after cylinder condensation is avoided. The line a, e shows the gain due to temperature at 25 per cent cut-off, by avoiding cylinder condensation up to cut-off, taken at 25 per cent, e, f, g shows the additional gain up to the point when steam is dry at release, point f; e, h shows the gain due to volume which commences when the steam is dry at cut-off. Now these lines, a, b, d and a, e, h, show a continuous gain when referred to the base line a, o, but if a line be drawn, a, n, showing the loss of boiler efficiency as the superheat increases, then by referring to this line as a base line, it will be seen that there would be

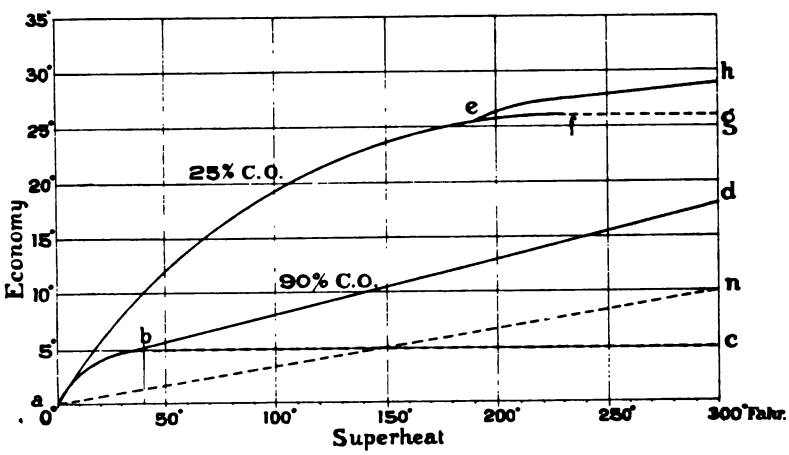


Fig. 6.

no great advantage in increasing the superheat above point e for 25 per cent cut-off, and that its most economical value depends on the slope of the line a, n. This slope will depend upon the type of boiler, and may be different from that shown on this diagram, but the steam lines, while not accurate, are reasonably so and it will probably be possible to lay them down for a simple locomotive in the near future; then, if a, n can be determined for any type of boiler, the total economy due to superheating can be shown and the desirable amount of superheat determined. One consoling fact in the experimental stage must be remembered — that no risk is being run of a loss, as whatever superheat is obtained is of value, and although if insufficient, the greatest economy is not obtained, the best results will have to be worked up to, as a sufficient amount of evaporative surface must be retained.

DESIGNS.

The designs of superheaters so far used are chiefly due to Mr. Wilhelm Schmidt, who has developed two distinct arrangements, both of which are of that type in which a portion of the number of flues is utilized for superheating. The design most generally used abroad, which is known as the Schmidt smoke-box superheater, is illustrated in Fig. 7, and its special feature consists in the use of a tube of large diameter leading from the fire-box to the front tube sheet, by which a considerable portion of the flue gases are delivered at a high temperature into an annular chamber at the front end, within which the superheater tubes are placed. The steam from the dry pipe passes into the rear end of a header, placed near the top of the smoke-box on the right side, which header is divided into a front and back portion by a transverse partition. From the back of the header the steam passes through the small superheater pipes to the rear end of a corresponding header on the left side, and from the front of that header through other superheater pipes to the front section of the right-hand header, and thence to the cylinders. The superheater pipes are curved to surround the gases flowing from the large tube, which then pass upward on each side and then into the smoke-box proper. As in all superheaters of this type, a damper is provided to close off the flow of gases through the superheater when the engine is shut off, as at that time there is no steam in the superheater pipes, and they would be damaged by the hot gases if they were allowed to pass through freely. While this type of superheater has been extensively used in Germany, it has only been applied to one engine in America (No. 548 on the Canadian Pacific Railway), and although the results obtained from it have been exceedingly satisfactory, and any desired amount of superheat can be obtained by an adjustment of the amount of gas passing through the large tube, it is doubtful whether it will actually make very much headway in this country. There is considerable complication in the front end, and a number of steam-pipe joints, which, while they have not given any trouble so far, are certainly objectionable, and since in the other design of superheater developed by Mr. Schmidt these difficulties are overcome, it appears probable that the latter, which is known as the smoke-tube superheater, will be the one generally employed. This design is shown in Fig. 8, and a later modification of it in Fig. 9, from which it will be seen that in the upper portion of the tube sheet, a number of large tubes — in this case twenty-two — are used in place of the ordinary 2-inch or 2¼-inch tubes. These large tubes are 5 inches diameter, reduced to 4 inches at the back tube sheet, and each contains two loops of 1¼-inch superheater pipes connected at the back end by steel return bends. The steam passes from the dry pipe to a transverse header in the smoke-box, which is divided by partitions into two portions, one for saturated and the other for superheated steam, and is arranged with a face on its lower side, having openings communicating with the saturated and superheated steam compart-

pressure of 55 pounds, obtained economies of from 20 to 45 per cent with steam superheated to from 410° to 490° F.

John Penn, before the Institute of Mechanical Engineers in 1859, reports on a condensing marine engine on the S. S. Valetta, 260 H.-P., boiler pressure 20 pounds, boiler heating surface 4,950 square feet, superheater forty-four 2-inch tubes in smoke-box, superheating surface 720 square feet, superheat 100° F. Saving, 20 per cent in fuel.

John Ryder, in a paper before the Institute of Mechanical Engineers, 1860, reports on a condensing marine engine on the S. S. Buster, boiler pressure 10 pounds, superheater two return-pipe over fire, superheat 144°. Saving, 25 per cent in fuel.

Bryan Donkin, article in *Engineering*, 1891, reports on a simple non-condensing horizontal engine. Boiler pressure 50 pounds, revolutions 220, superheat 50° F. Saving, 15 to 27 per cent, dependent on cut-off (probably water consumption). Higher temperature of cylinder walls noted.

W. H. Patchell, paper before Institute of Mechanical Engineers in 1896, reports on a horizontal tandem compound condensing engine, 300 H.-P., cylinders 18 inches and 36 by 48 inches. Boiler pressure 100 pounds; superheater, Hick, Hargreaves & Co., superheat 42° to 55°. Economy in water, 9.6 per cent; in coal, 19 per cent (indicates part gain due to more efficient boiler results, water evaporated per pound coal, increase 13 per cent).

Other tests on Lancashire boilers show a very similar result, considerable gain being shown in water evaporated per pound of coal.

There are any number of similar instances in stationary practice, and it is significant that such decided gains have invariably been obtained from simple non-condensing engines, and this fact would lead to the expectation of decided benefits in locomotive work.

The tests of the first locomotive equipped, Hanover No. 74, which were reported by Mr. Garbe in his paper of 1902, showed excellent results in comparison with two similar, but compound locomotives Nos. 73 and 49. On a nine days' test from October 16 to 25, 1901, running passenger trains averaging thirty-five axles and 360 tons from Grunewald to Saumerfauld and back (104 miles), the superheated locomotive consumed per train mile 34.2 pounds of coal and 206 pounds of water, with an evaporation of 6.05 pounds of water per pound of coal. The compound locomotives consumed 37.8 and 38.2 pounds of coal, respectively, and 279 pounds of water per train mile, the evaporation in their case being 7.37 and 7.30 pounds of water per pound of coal. The compound locomotives therefore required 11½ per cent more coal and 30 per cent more water than the superheater, but the boiler of the latter was evidently less efficient, as an evaporation of 7.35 pounds saturated steam would equal 6.60 pounds superheated 200°. Other tests with locomotives 2069 and 2070 showed equally good results, a saving of about 15 per cent in coal being obtained with a steam temperature of about 520°. A large number of

indicator diagrams from these tests are shown in Mr. Garbe's paper, and they are exceedingly satisfactory.

In 1901, trials were made by Mr. Von Borries on the Royal Hanover Railway, between a four-cylinder compound, No. 11, a two-cylinder compound, No. 38, and the first engine fitted with the smoke-box superheater, No. 86. These engines were all 2-4-0 passenger engines with driving wheels 78-inch diameter, No. 11 having 13-inch and 20½-inch cylinders, No. 38, 18.1-inch and 26.8-inch cylinders, and No. 86, 18.9-inch. The length of run from Hanover to Stendel was 93½ miles. In these tests the consumption of coal and water and evaporation was as follows:

Engine No.	Coal per Mile.	Water per Mile.	Water per l.b. Coal.	Relative Consumption	
				Coal.	Water.
11	38.8	280	7.27	98.0	110
38	37.8	294	7.78	95.5	115
86	39.6	255	6.44	100.	100

The superheater engine, while showing a saving of 10 to 15 per cent in water as compared with the compounds, showed a loss of 2 to 4½ per cent in coal, but this test has occasioned a large amount of controversy in Germany, and Mr. Garbe has pointed out that on the run on which these trials were made, the trains were lighter and the line less severe than in the case of the trials of engine No. 74, yet the coal and water consumption in the case of engine No. 86 was considerably greater than that of No. 74. Any one desiring a critical analysis of these tests can be gratified by referring to the Bulletin of the International Railway Congress for February, 1904, in which translated papers by Mr. Teuscher and Otto Berner were published.

In 1902 Mr. Von Borries made further trials between two new four-cylinder compounds, Nos. 17 and 18, two new superheated simples of the Schmidt smoke-box type, Nos. 439 and 440, and one two-cylinder compound, No. 42. The grate area of all these engines was the same, 24.43 square feet, and the heating surface of the three types 1,277, 1,134 and 1,345 square feet, respectively. The boiler pressure of Nos. 17 and 18 was 210 pounds and that of the others was 180 pounds. A large number of runs were made between Stendel and Hanover, the mean speed over a distance of about seventy-five miles averaging fifty-four to fifty-six miles per hour. The drawbar pull for the train was calculated by the formula:

$$T = W(0.8 + V\frac{V+80}{17300})$$

that of the locomotive by:

$$T = W(1.9 + V\frac{V+48}{5760})$$

where T is tractive force in pounds, W weight in tons (2,000 pounds), and V, speed in miles per hour. The average temperature of the superheated steam in Nos. 439 and 440 was 527°, and the averages of the more important results were as follows:

Description.	Nos. 17 and 18	Nos. 439 and 440.	No. 42.
Number of runs	20.	22.	12.
Duration of run, minutes	112.3	108.5	114.7
Net time of trip, minutes	107.3	103.5	109.7
Mean speed for 75 miles	54.8	56.4	54.
Weight of train, tons	315.	302.	284.
Water per round trip, pounds	51,160.	45,780.	50,100.
Coal, per round trip, pounds	6,662.	7,030.	6,472.
Water per mile, pounds	35.7	37.6	34.6
Coal per mile, pounds	274.	245.	268.
Water evaporation by coal	7.67	6.54	7.78
Relative evaporation	117.	100.	119.
Coal per H. P. hour, total pounds	2.08	2.17	2.32
Relative consumption	96.	100.	107.
Coal per H. P. hour at drawbar, pounds	3.65	3.76	4.46
Coal per square foot grate per hour, pounds	76.3	83.3	73.2

In this test the superheater simple obtained results practically equal to the four-cylinder compound and superior to those of the two-cylinder. It was also worked rather harder, the average speed of the runs made by it being 2.9 per cent greater than those made by Nos. 17 and 18. The boiler performance is again inferior to the engines without superheater, although better than that usually obtained in America, but as the superheat was about 150°, had the boiler efficiency been the same as on Nos 17 and 18, the evaporation would have been 7.1 pounds of water per pound of coal and in place of the four-cylinder compound showing a gain in coal per total horse-power hour of 4 per cent, it would have shown a loss of 3 per cent. As a confirmation of this test, Mr. Von Borries states that the consumption of coal per mile for the same engine in regular passenger service was, during six weeks, 39.42, 40.16 and 39.81 pounds per mile for these types respectively, figures which agree fairly well with those obtained on trial. In some similar trials on the Halle Railway between the same class of four-cylinder compounds and simple superheaters, the results were as follows:

Description.	Four-cylinder Compound.	Simple Superheater.
Coal pounds per mile	38.9	37.9
Relative consumption	103.	100.
Water pounds per mile	270.2	226.5
Relative consumption	119.	100.
Evaporation	6.96	5.98
Relative evaporation	116.5	100.

In this test, the superheater engine has a slight advantage in coal consumption, but there is the same large difference between the water and coal figures, showing a decreased boiler efficiency in the superheater.

Some 0-8-0 freight engines were also tested on the Royal Saarbrucken Railway, the superheater engines being simple and weighing 122,000 pounds, the two-cylinder compounds weighing 117,000 pounds, the train loads being practically proportional. The results were stated per 1,000 miles per axle and were as follows:

Description.	Compound.	Superheater.
Coal burned, pounds	605.6	567.3
Relative performance	107.	100.
Water used, pounds	4,459.	4,070.
Relative consumption	110.	100.
Evaporation	7.38	7.18
Relative evaporation	103.	100.

It will be noticed that the boiler performance of the superheater in this case is decidedly better and that while the economy in water is not as great as in previous trials, yet the coal economy is better. This may be due to the engine not having been worked as hard as in the previous trials, and consequently those gases passing through the superheater would not leave it at so high a temperature. These tests have been presented at some length to show the possibility of a substantial economy in water being neutralized by a loss in boiler efficiency, and by this is not meant the decrease in the evaporation due to the additional amount of heat in the steam delivered to the engine, but a further decrease, which can only be due to one of two causes, the gases that pass through the superheater leaving it at too high a temperature or the reduction in the number of flues used for evaporative purposes increasing the velocity of the gases in those flues so that their temperature, when leaving, is too high. The latter reason does not appear possible and the Schmidt smoke-box superheater is certainly very liable to lead to the first, although it can be avoided by proper adjustment, and it appears probable that the poor boiler results in these trials may be accounted for in this way. It should be noted, therefore, that the superheater simples showed an economy in water of 14 to 15 per cent over a four-cylinder balanced compound in passenger service which, allowing an average of 150 per cent of superheat, would permit of an economy in coal of about 7 per cent, and that the average coal consumption in passenger service is actually the same, and in freight service better than the compound engine. An extensive test was carried out by Mr. Strahl, of the Breslau District of the Prussian State Railways, between two 2-4-0 passenger locomotives, No. 9 simple and No. 54 compound, equipped with the Pielock superheater, and two similar engines, No. 4 simple and No. 60 compound, using saturated steam. The results are given in the following table:

Description.	No. 4.	No. 9.	No. 60.	No. 54.
Diameter of cylinder	16½	16½	18½ and 26¾	18½ and 26¾
Stroke	23¾	23¾	23¾	23¾
Diameter of drivers	78″	78″	78″	78″
Heating surface, square feet	1,349	1,123	1,270	1,044
Superheater surface, square feet	226	226	226	226
Grate area	24.43	24.43	24.76	24.76
Average weight of train, including engine and tender	283	283	309	309
Distance run, miles	1,193	1,193	2,360	2,360
Working pressure, pounds	170	170	170	170
Temperature of superheated steam in dome	500	500	446	446
Temperature of feed water	50°	50°	50°	50°
Average consumption of steam per hour, pounds	9,568	8,069	11,618	10,459
Average consumption of coal per hour, pounds	1,195	1,047	1,574	1,519
Economy of water, per cent	16	16	10	10
Economy of coal, per cent	12.3	12.3	3.5	3.5
Water evaporation per pound coal	8	7.70	7.70	6.88

In these tests the saving in water was accompanied by a corresponding saving in fuel, although in the compound superheater the boiler performance drops off a little, although the superheat is low and, in fact, the superheat in these trials was only moderate and not as high as that advocated by Schmidt. In an article written by Mr. Strahl giving the results of his experiments he arrives at the result that the locomotive with the superheater used almost exactly the same volume of steam as the locomotive without, and Mr. Strahl has also advised that this approximation holds very closely for other engines using superheated steam. He states that for several months some 0-8-0 engines with Schmidt smokebox superheater have been compared with the same class without the superheater and that the resulting economy in water has been 25.3 per cent and in coal 15.25 per cent. On the basis of equal volumes with the degree of superheat obtained, the figures would have been 24 and 17 per cent respectively. An interesting result arrived at by Mr. Strahl is that flat slide valves worked satisfactorily up to 520° F. The German trials described above are remarkably uniform in one respect — the considerable water economy effected by superheating, and they also show that while a falling-off in boiler efficiency must be guarded against, it need not occur, at any rate, beyond 2 to 5 per cent. In the tests made by Mr. Von Borries, it must be remembered that the engine with which the superheater simple was compared is the most efficient type of compound, that the water economy shown in comparison with it is a high recommendation for the superheater, and in view of the probable improvements in boiler performance, it will, no doubt, in the future, be possible to show a corresponding economy in fuel.

Turning from the results obtained abroad to those in America, the only figures so far available are those on the Canadian Pacific Railway and on this road the records available are those obtained in service over a considerable period. These results, after all, must be the deciding ones, as in view of the influence of the boiler efficiency on the net economy, isolated tests will always be more or less unsatisfactory. It is possible to

determine the water consumed per unit of power developed with considerable accuracy, but in determining the water evaporated per pound of coal, a factor must be taken into account that is independent of the boiler, and pretty near everything else on the road, in the efficiency of the fireman. It is quite possible, on a test, to obtain an evaporation that is decidedly better than that realized day after day in service, and while no doubt careful tests are desirable, and it is the intention to carry them out as soon as a dynamometer car is available for the purpose, yet the service results are so far satisfactory and are interesting as showing the economy actually obtained.

The records from engine No. 548 extend over a period of seventeen months, during which time this engine was compared with similar simple and Vauclain compounds in freight service and with simple and two-cylinder Pittsburg compounds in passenger service. The dimensions of the various engines are as follows:

Engine No	548	616	595	634	482
Type	4-6-0	4-6-0	4-6-0	4-6-0	4-6-0
Kind	Simple S. H. Schmidt S'box.	Simple.	Compound 2-cylinder Pittsburg	Simple.	Compound. 4-cylinder Vauclain.
System					
Cylinders	18 x 24	18 x 24	20 & 30 x 24	18 x 24	13½ & 23 x 24
Drivers	62"	62"	62"	62"	62"
Heating surface, fire tubes and fire-box, square feet	1,116	1,291	1,291	1,428	1,614
Grate area	23.44	23.44	23.54	28.54	28.54
Boiler pressure, pounds	180	180	180	180	200
Weight on drivers, pounds	96,800	95,400	96,800	94,350	94,100
Total weight, pounds	124,000	119,250	123,400	119,325	129,225
Superheating-surface, square feet	307				

These engines were compared for periods in which they were running in corresponding service to No. 548 between Montreal and Smith Falls, a practically level division with rolling grades with a maximum of 0.5 per cent, and the results were as follows: The column marked "Relative Economy," in each case showing the amount of coal consumed by engine No. 548 as compared to the engine with which it was tested:

	Engine.	Engine, Miles.	Ton-Miles, Thousands	Coal, Tons.	Coal, per 1,000 Ton-Miles.	Relative Economy.
May, 1903, to December, 1903	548	34,493	33,183	1,541¾	93	81.5
Freight	482	31,857	30,457	1,741¾	114	100.
January, 1904, to May, 1904	548	16,812	14,404	931	129	74.
Freight	616	15,722	13,248	1,167	176	100.
June, 1904, to September, 1904	548	15,763	2,451	467¾	382	81.5
Passenger	595	16,128	2,560	600	469	100.
	634	16,854	2,750	680½	495	105.

Noting that Nos. 616 and 634 are simple engines and Nos. 595 and 482 are compounds, these results show satisfactory agreements and would show that this engine consumed about 75 per cent of the coal required by

a simple engine, and 82 per cent of that required by a compound in similar service. The superheat obtained in this engine is, however, high, running from 550° to 650° according to conditions, and it may be considered as representing the extreme limit to which superheating can be conveniently carried. There is no doubt that the results that have been obtained are exceptionally economical and the engine has been a favorite with the men handling it in any service. The valve and cylinder arrangements of this engine were designed by Mr. Schmidt and have given entire satisfaction at the temperature mentioned above, although when the superheat was raised above 700° a certain amount of trouble was experienced with the lubrication and packings.

The results from engines 1000 and 1300 extend over a period of nine and eleven months respectively, during which time these engines were compared with engines identical in every respect except that of not being equipped with a superheater. The dimensions of these engines are as follows:

Engine No	1000	996 and 997	1300	1319
Type	4-6-0	4-6-0	4-6-0	4-6-0
Kind	Compound S. H.	Compound	Compound S. H.	Compound.
System	2-cyl. Schmidt fire tube	Pittsburg 2-cyl.	2-cyl. Schenectady, fire tube	2-cyl. Schenectady,
Cylinders	22 and 35 x 26	22 and 35 x 26	22 and 35 x 30	22 and 35 x 30
Drivers	63"	62"	62"	62"
Heating surface, fire tubes and firebox, square feet.	1,888	2,420	2,492	3,065
Superheating surface, sq. ft	350	.....	390	.....
Grate area, square feet	33.02	33.02	44.08	44.08
Boiler pressure, pounds	210	210	200	200
Weight on drivers, pounds	129,000	128,000	141,000	141,000
Total weight, pounds	172,000	169,000	192,000	190,000

Engine 1000 was compared with Nos. 996 and 997 for periods in which they were running in corresponding service between Montreal and Smith Falls in freight service. Engine 1300 was compared with No. 1319 in corresponding service between Chalk River and North Bay, and North Bay and Cartier; these divisions are very similar, Chalk River to North Bay being an undulating road with several grades four to seven miles long with occasional stretches of 1 per cent, but more generally 0.6 to 0.8 per cent, the total rise on the division being 135 feet. From North Bay to Cartier, the road is undulating except for one rise of 480 feet in sixteen miles, the limiting grades being 1 per cent and the total rise 230 feet. The results were as follows, arranged as for engine No. 548:

	Engine.	Engine, Miles.	Ton-Miles. Thousands	Coal, Tons.	Coal, per 1,000 Ton-Miles.	Relative Economy.
MONTREAL TO SMITH'S FALLS.						
January, 1904, to July, 1904	1,000	21,567	25,321	1,271½	100	72
	997	19,662	23,278	1,499½	129	100
August, 1904, to September, 1904	1,000	3,740	4,657	188½	81	70
	996	5,666	7,026	409¾	116	100
CHALK RIVER TO NORTH BAY.						
November, 1903, to September, 1904	1,300	22,987	17,075	1,127½	132	90
	1,319	19,983	15,091	1,112½	147	100
NORTH BAY TO CARTIER.						
November, 1903, to September, 1904	1,300	10,964	9,887	550½	111	84
	1,319	10,521	9,249	616¼	133	100

These results are rather more favorable to the superheater engines than would have been expected, especially in the case of engine 1000, where it will be seen that this engine gave considerably better comparative results than No. 1300. These engines also being equipped with the smoke-tube type of superheater did not obtain the same degree of superheat as No. 548, generally running from 500° to 550°. There was a certain amount of leakage from the boiler of 1000, 996 and 997 class during the period, which makes the comparison of less value than those for 548 and 1300, but in spite of this, the results are evidently satisfactory.

The results from twenty Schmidt smoke-tube superheaters and twenty-one Schenectady superheaters have been obtained over a period of four months. These engines could not be compared with similar engines, but they are compared with the 1300 class referred to previously and with a class of compound consolidations termed the 1200 class. As will be seen by the table below, these consolidations, although lighter, are a very similar engine in every respect to the superheaters, as they are comparative in their dimensions and have the same grate area and type of boiler. The dimensions of these engines are as follows, the Schmidt superheater being the 1600 and the Schenectady superheater the 1621 class:

	1200	1600	1621
Type	2-8-0	2-8-0	2-8-0
Kind	2-cyl. Compound.	Simple S'heater.	Simple S'heater.
System	Schenectady.	Schmidt Smoke-tube	Schenectady Smoke-tube.
Cylinders	22 and 35 x 28	21 x 28	21 x 28
Drivers	57"	57"	57"
Heating surface, fire tubes and firebox, square feet	2,218	2,381	2,870
Superheating surface	.....	375	340
Grate area	43.64	43.64	43.64
Boiler pressure, pounds	200	200	200
Weight on drivers, pounds	143,000	164,000	164,000
Total weight, pounds	162,000	186,000	186,000

The results obtained from these engines were as follows, the number of engines working being the actual number of different engines of the class included in the figures each month and the comparative economy

being that of the various engines compared with the 1200 class where possible, or if none of those engines were working, with the 1300 class, and in one case with the 1621 class. The column 1600 over 1621 shows the percentage of economy, or if negative, the loss of the 1600 over the 1621 class:

	Engine.	No. of Class Running	Ton-Miles, Thousands	Total Coal, Tons.	Coal per 1,000 E. ti. Ton-Miles.	Relative Economy.	1600 to 1621
CHALK RIVER TO NORTH BAY.							
January	1200	12	7,077	717½	202	100	21
	1300	1	805	80½	199	98	
	1600	5	5,111	410½	160	79	
	1621	9	10,669	1,075	201	100	
February	1200	1	202	17½	173	100	14
	1300	1	1,354	117½	173	100	
	1600	6	7,542	612½	162	93	
	1621	8	8,728	824½	188	108	
March	1200	1	316	24½	155	100	13
	1300	1	770	56	145	93	
	1600	6	6,175	423½	137	88	
	1621	6	7,095	560½	157	101	
April	1600	5	6,179	374½	121	93	7
	1621	6	9,886	645½	130	100	
NORTH BAY TO CARTIER.							
January	1200	10	6,393	499	156	100	4
	1300	1	713	48½	136	87	
	1600	4	2,008	146	145	93	
	1621	6	9,307	708½	152	97	
February	1200	2	1,590	137½	172	100	16
	1300	1	565	44½	156	91	
	1600	6	6,043	423¾	140	82	
	1621	8	5,052	429	167	97	
March	1200	3	1,377	100½	145	100	14
	1300	1	728	50	137	95	
	1600	5	4,825	294	121	83	
	1621	6	5,360	378½	141	97	
April	1200	1	365	26	143	100	8
	1300	1	191	9¾	102	71	
	1600	5	6,322	367½	116	81	
	1621	6	5,599	352¾	126	88	
CHAPLEAU TO WHITE RIVER.							
January	1300	3	3,755	340½	181	100	25
	1600	13	13,956	1,267¾	181	100	
	1621	5	612	74½	243	132	
February	1300	4	2,096	239	177	100	
	1600	9	13,226	1,050½	158	89	
March	1300	3	4,821	400¾	164	100	
	1600	10	19,106	1,348	141	86	
April	1300	4	2,518	193	153	100	
	1600	9	11,894	738¾	124	81	
CARTIER TO CHAPLEAU.							
January	1300	3	3,373	322¾	191	100	12
	1600	11	14,547	1,209½	166	87	
	1621	7	1,170	110½	188	98	
February	1300	3	3,979	332¾	167	100	
	1600	9	13,176	996¾	151	90	
March	1300	3	3,305	246½	149	100	6
	1600	11	21,942	1,450	136	91	
	1621	1	265	17	128	86	
April	1300	3	2,726	204¾	150	100	
	1600	9	12,814	766¾	119	79	

	Engine.	No. of Class Running	Ton-Miles. Thousands	Total Coal. Tons.	Coal per 1,000 E. G. Ton-Miles.	Relative Economy.	1600 to 1621
MEGANTIC TO FARNHAM.							
January	1200	6	759	124½	328	100	
	1621	7	13,595	2,164½	318	97	
February	1200	4	879	177½	403	100	
	1621	7	12,639	2,060½	326	81	
March	1200	1	170	32	378	100	
	1621	8	15,481	2,153½	278	74	
April	1200	1	1,033	152½	295	100	
	1621	8	13,923	1,320½	261	89	
FARNHAM TO OUTREMONT.							
January	1200	8	1,120	126½	225	100	
	1621	4	1,800	186	206	92	
February	1200	4	1,754	211	240	100	
	1621	7	801	105½	263	109	
March	1200	2	1,228	112½	183	100	
	1621	3	821	83	202	110	
April	1200	1	49	5½	224	100	
	1621	1	52	6	230	102	
NEWPORT TO FARNHAM.							
January	1200	4	611	102½	334	100	
	1621	6	1,807	261½	289	87	
February	1200	2	946	137	289	100	
	1621	4	1,184	177½	300	104	
March	1200	2	1,036	148½	286	100	
	1621	1	282	37½	264	92	
BROWNVILLE TO MEGANTIC.							
January	1200	12	5,364	677	252	100	
	1621	6	12,113	1,429½	236	94	
February	1200	12	6,991	982½	281	100	
	1621	6	4,686	801½	342	122	
March	1200	12	7,907	949½	240	100	
	1621	4	9,447	1,064	225	94	
April	1200	14	6,319	720½	228	100	
	1621	4	7,837	923½	235	103	

Reference has already been made to the nature of the divisions, Chalk River to North Bay, and North Bay to Cartier, shown in the above table; Cartier to Chapleau and Chapleau to White River are practically similar, having undulating grades with 1 per cent limit, and a maximum rise or fall of 200 feet; both divisions are, very largely, short grades, with very little level track, but the net rise is only 110 feet in the latter case, and the former is practically level. Farnham to Megantic is a very heavy division in the direction of traffic, rising 750 feet in thirty-three miles, with grades of 0.7 to 1.0 per cent, undulating seven miles with drop of ten feet, limiting grades 1 per cent, falling 135 feet in five miles, limit 1 per cent, undulating with short 0.6 and 1 per cent grades twenty-two miles with drop of 200 feet, rising 330 feet in six miles, limit 1.3 per cent, down 330 feet in six miles, limit 1.3 per cent, rising 640 feet in forty-seven miles with limiting grades of 1.3 per cent and drops of 232 and 400 feet, besides smaller ones.

Farnham to Outremont is undulating with short grades of 0.6 and 0.75 per cent. Farnham to Newport is heavy in direction of traffic, rising 236 feet in twenty miles, limiting grade 1 per cent, 119 feet in four miles

with grades 1.4 and 1.66 per cent, dropping 162 feet in seven miles, 1 per cent grades, undulating eighteen miles, rising 422 feet in eleven miles, 1.5 per cent grades and dropping 255 feet in four miles, 1.5 per cent grades. Brownville to Megantic in direction of traffic, rising 640 feet in fifteen miles with limit of 1.2 per cent, dropping 700 feet in thirteen miles, grades up to 1.2 per cent, undulating fifty-eight miles with grades up to one and a half miles long of 1.0 per cent, dropping 480 feet in thirteen miles, 1 per cent, undulating eleven miles, dropping 370 feet in seven miles, grade 1 per cent.

From an inspection of this statement, which is simply an analysis of the regular road records for five months, it will be seen that the results obtained from the 1600 class are decidedly superior to those obtained from the 1621 class. This is due to the higher superheat in the former engine, which is about 100° as against 50° in the case of the latter; in neither is as much obtained as is desirable, but still good results have been obtained. The only case in which 1621 shows the better results is for a round trip in March, and it is not reasonable to place reliance in coal figures for one trip on account of no proper allowance being made for the coal on the tender. There is, however, a very general agreement that the 1621 class are equally as economical as the compounds and the 1600 class about 10 per cent better, and while it is impossible to say definitely that this is due to the superheat, yet the fact remains that the 1200 and 1300 class engines were previously the most economical on fuel on the road and yet, as shown, the 1600 class have given superior results. No doubt, the experience so far gained is hardly sufficient for a definite conclusion, but it certainly can be said that the results to date are exceedingly satisfactory.

GENERAL CONCLUSIONS.

The use of superheated steam does not entail the multitude of practical difficulties that so generally accompany any invention or improvement that is introduced to improve the economic results obtained from a locomotive, and indeed, it is probable that as experience with its application develops, some of the expenses that are incurred in the locomotive of to-day will be diminished rather than increased. There would only appear to be two possible sources of additional cost, the wear of valves and cylinders due to defective lubrication, and the cost of maintaining the superheater itself. So far as has been learned at present, the lubrication of superheater engines is not different from that of other engines, with the exception that the lubrication must be accomplished, and it is not sufficient to hope that the oil gets to the designed spot. For this purpose a positive feed lubricator is required, and this should preferably be provided with six feeds, so that pipes may be led to each end of the valve and to the cylinder. It should also be possible to vary considerably the amount of oil fed per minute, as superheater engines, even more than those of the ordinary type, require more oil when working slowly at long

cut-offs, than at other times, on account of the high temperature of the steam being maintained throughout the stroke. This can be effected either by supplementary oiling or by an easy adjustment of the lubricator allowing a large amount of oil to be fed at low speed, but the latter will be preferable if obtained without complication. With proper lubrication there appears to be no additional wear of valves or pistons, and while a special mixture of metallic packing must be used, it has given, if anything, less trouble on the superheaters than on the other engines. On Engine 548 in which the steam was superheated as high as 700°, it was found that the ordinary valve oil was not suitable and that the rod packings would melt out, but by reducing this from 550° to 600°, these troubles were not experienced, and no difference is noticed between an operation of this and an ordinary engine. The valves used on the 548 are Mr. Schmidt's design, but with split ring packing in place of the solid ring used in Germany, so that they are practically similar to the piston valves in general use, except in their being of small diameter, six inches for an 18-inch cylinder, and double ported. The packing rings, in place of being narrow, are comparatively wide and on the surface there are several water grooves. These rings have given exceedingly good service, but in view of the successful use of split rings it is difficult to see any reason why valves of the ordinary design should not be entirely suitable for superheated steam, the only point to consider being whether small double ported valves would not be preferable to the large single ported valves at present in use, and whether wide rings with water grooves would not give better results than narrow plain rings. It is natural that, on account of the reduced weight of the superheated steam, a smaller admission area can be used than that required for saturated steam, but for equal flows under equal heads, the rate is only 10 to 9 and 8, for steam superheated 100° and 200° respectively, so that the dimensions adopted by Mr. Schmidt must be entirely ascribed to the use of double ported valves. Those engines on the Canadian Pacific having smoke-tube superheaters which have not developed the same degree of superheat as Engine 548, have given, so far, no trouble with their valves, pistons and packing, when properly lubricated, and while there is room for considerable improvement in positive feed lubricators before an entirely suitable design is obtained, it is safe to say that with proper lubrication there will be no greater expense in maintaining the engine on account of using superheated steam.

The repairs to the superheater proper are at present difficult to determine; the smoke-box superheater certainly entails an additional expense when flues are renewed, as it has to be entirely dismantled in order to get at the tube sheet, but while it is said to have given some trouble in service in Germany, such has not been the case in three years' experience on the Canadian Pacific Railway. Some trouble was at first experienced with the joint between the large tube and the back tube sheet, but this was overcome by properly thinning the edges of the lap, as in fire-box construction. There has been no leakage from the various joints

MR. ANGUS SINCLAIR: I move that the paper be received and spread upon the minutes. (Motion seconded and carried.)

PROF. W. F. M. GOSS: While those who have had experience in the use of superheated steam are getting ready to speak, I want to express my appreciation for this paper which Mr. Vaughan has presented to us. I think it is a scholarly and at the same time easily understood contribution, which should and which undoubtedly will have an important influence in shaping practice in the design of locomotives. I see nothing to add to its statement of theory, and being void of experience in this line I can add nothing to the facts presented.

MR. C. A. SELEY: I second what Professor Goss has said in every way. I was very glad to notice a sentence at the bottom of page 17, which I will read: "One consoling fact in the experimental stage must be remembered — that no risk is being run of a loss, as whatever superheat is obtained is of value, and, although if insufficient, the greatest economy is not obtained, the best results will have to be worked up to, as a sufficient amount of evaporated surface must be retained." That is very consoling to us, as we have recently obtained six superheated locomotives. They have just been put into service so that I am unable to say what the result will be. Although we may not have a very high degree of superheating, we have already experienced troubles in lubrication which I find have not been satisfactorily worked out. If we can successfully work a sight-feed lubricator with a moderate degree of superheating, I think a large part of the difficulties on the road will be eliminated.

MR. F. M. WHYTE (N. Y. C. & H. R.): I would ask Mr. Vaughan what percentage of saving they have found on the Canadian Pacific. I think that the percentages as given on pages 21 and 22 are somewhat theoretical percentages, and also the conclusions on page 7; but what it is desired to know is the actual percentage of saving they have secured.

MR. H. H. VAUGHAN: The actual figures are given on pages 30 and 31. These are the actual figures from our coal records.

MR. WHYTE: What are these in percentages?

MR. H. H. VAUGHAN: You can not give a saving in per-

increase in the cost and trouble of boiler maintenance. By superheating, the initial pressure becomes of less importance and with the proper amount of superheat, it will be possible to return to pressures of 175 pounds or less, without any appreciable loss in economy, and with a relief from those boiler troubles, which have become more serious as the pressure has increased, it is probable that the saving from this cause alone, will overbalance any additional expense connected with the maintenance of the superheater.

Herr Garbe, in addition to the reduction of boiler pressure, advocates a still further advance, namely, the enlarging of the cylinders sufficiently to develop the full power of the engine, with cut-offs of 30 to 33 per cent. A reduction in power is then effected chiefly by throttling, the cut-off remaining practically constant. This method may possibly prove advisable in American passenger work, but it does not appear practicable for freight locomotives. It is evidently impossible to develop the same tractive power with a given weight on drivers, with a cut-off of 30 per cent as with 80 per cent, since there is a greater variation in the maximum effort in the former case, and with the conditions here prevalent, where the loading is so closely equal to the capacity of the engine, a reduction in capacity could not be tolerated. A reduction in boiler pressure, however, when accompanied by a corresponding increase in the cylinder dimensions, does not affect the tractive power and would appear to be a decided advantage.

In general, therefore, it may be assumed that the maintenance of locomotives using superheated steam will not be necessarily greater than that of ordinary locomotives of similar size, as although certain additional expenses are introduced, these are offset by economies in other directions, and the net result will not be very much different. If this position is correct, the advisability of superheating depends entirely on the relation between the initial additional cost and the saving obtained, and as, at present, the cost of applying a superheater is about $1,000 per engine, and the tendency will be rather to reduce this amount than increase it, it is evidently a very good investment. A 200,000-pound freight engine making 30,000 miles per annum, will burn about 2,500 tons of coal, which at $2 per ton, costs $5,000, so that evidently a saving of 10 per cent will pay 50 per cent of the additional cost per annum, and it appears perfectly safe to state that with a superheater at least that amount can be saved. While slightly more expensive, at first cost, than compounding, there is in the application of superheated steam a possible development in locomotive engines, which obtains at least as great an economy in fuel, which is practicable and without complication in its construction, which costs no extra for maintenance, does not reduce the efficiency of a locomotive in any way as a mover of freight, and which, without any desire to appear too enthusiastic, certainly promises to become one of the greatest steps in the direction of economy that has been introduced for many years past.

MR. ANGUS SINCLAIR: I move that the paper be received and spread upon the minutes. (Motion seconded and carried.)

PROF. W. F. M. GOSS: While those who have had experience in the use of superheated steam are getting ready to speak, I want to express my appreciation for this paper which Mr. Vaughan has presented to us. I think it is a scholarly and at the same time easily understood contribution, which should and which undoubtedly will have an important influence in shaping practice in the design of locomotives. I see nothing to add to its statement of theory, and being void of experience in this line I can add nothing to the facts presented.

MR. C. A. SELEY: I second what Professor Goss has said in every way. I was very glad to notice a sentence at the bottom of page 17, which I will read: "One consoling fact in the experimental stage must be remembered — that no risk is being run of a loss, as whatever superheat is obtained is of value, and, although if insufficient, the greatest economy is not obtained, the best results will have to be worked up to, as a sufficient amount of evaporated surface must be retained." That is very consoling to us, as we have recently obtained six superheated locomotives. They have just been put into service so that I am unable to say what the result will be. Although we may not have a very high degree of superheating, we have already experienced troubles in lubrication which I find have not been satisfactorily worked out. If we can successfully work a sight-feed lubricator with a moderate degree of superheating, I think a large part of the difficulties on the road will be eliminated.

MR. F. M. WHYTE (N. Y. C. & H. R.): I would ask Mr. Vaughan what percentage of saving they have found on the Canadian Pacific. I think that the percentages as given on pages 21 and 22 are somewhat theoretical percentages, and also the conclusions on page 7; but what it is desired to know is the actual percentage of saving they have secured.

MR. H. H. VAUGHAN: The actual figures are given on pages 30 and 31. These are the actual figures from our coal records.

MR. WHYTE: What are these in percentages?

MR. H. H. VAUGHAN: You can not give a saving in per-

centages always. It is a fact that on all of our divisions our coal goes up about forty to fifty per cent in winter, per thousand ton-miles, compared with summer. You will see that in such a case it is not going to do any good to worry about coal consumption, unless an engine makes a lot of mileage on a section. You will see that these tables are all made out according to section, from Chalk River to North Bay, 120 miles, and each division is put down separately.

MR. WHYTE: What I would like are the percentages of saving.

MR. H. H. VAUGHAN: It is not a fair comparison to compare two divisions, like North Bay to Cartier, and Chapleau to White River. The difference in the topography of the lines is enough to cause any comparison to be invalid. I would not ascribe any value at all, for instance, to an item like the consumption of the 1300 class for April, from North Bay to Cartier, where they only burned 9¾ tons of coal. While these records were prepared with reasonable care, I would not guarantee the accuracy of this one within a couple of pounds in running.

MR. WHYTE: After your experience with the superheater what is your opinion concerning the amount of saving?

MR. H. H. VAUGHAN: In the Schenectady superheater we obtain about 10° to 15° superheat, measured in the branch pipe with a mercury thermometer — that may be a little low, as there may be a certain amount of cooling effect on the thermometers, but our feeling is that this superheater is doing as well as our two-cylinder compounds. The other superheater gave 100° of additional superheat. You can look down the column on page 30, and you will see a series of results covering the engines from 1600 to 1621 class. That shows the saving of the 1600 class on which are the Schmidt superheaters, and the 1621 class, on which are the Schenectady superheaters. There is only one case where the Schenectady is better than the Schmidt. Going down the same column, you will note that from month to month the relative economy of the 1600 to the 1621 is given as 21, 14, 13, 7, etc., and I think we are justified in assuming that we have about ten per cent greater efficiency on the Schmidt than in the others. That would therefore be the saving as compared to a compound.

We have some tests we have just made in which we have obtained each mile the branch-pipe pressure and the degree of superheat, also we have measured the temperature of the gases coming out of the superheater tubes and the temperature of the gas coming out of the fire tubes, to see how much heat we were wasting in the gas coming out of the superheater tubes. I would like these diagrams included as part of my remarks, as I think they are interesting. These tests show about 390° to 415° in the Schenectady, and about 475° to 490° in the Schmidt, showing a difference of temperature of 100° in the gases in the front end coming out. I feel sure we are getting about ten to fifteen per cent improvement over the compound with the Schmidt superheater, but I am not sure whether it is due simply to the superheat. All we know is that we are getting that increased economy.

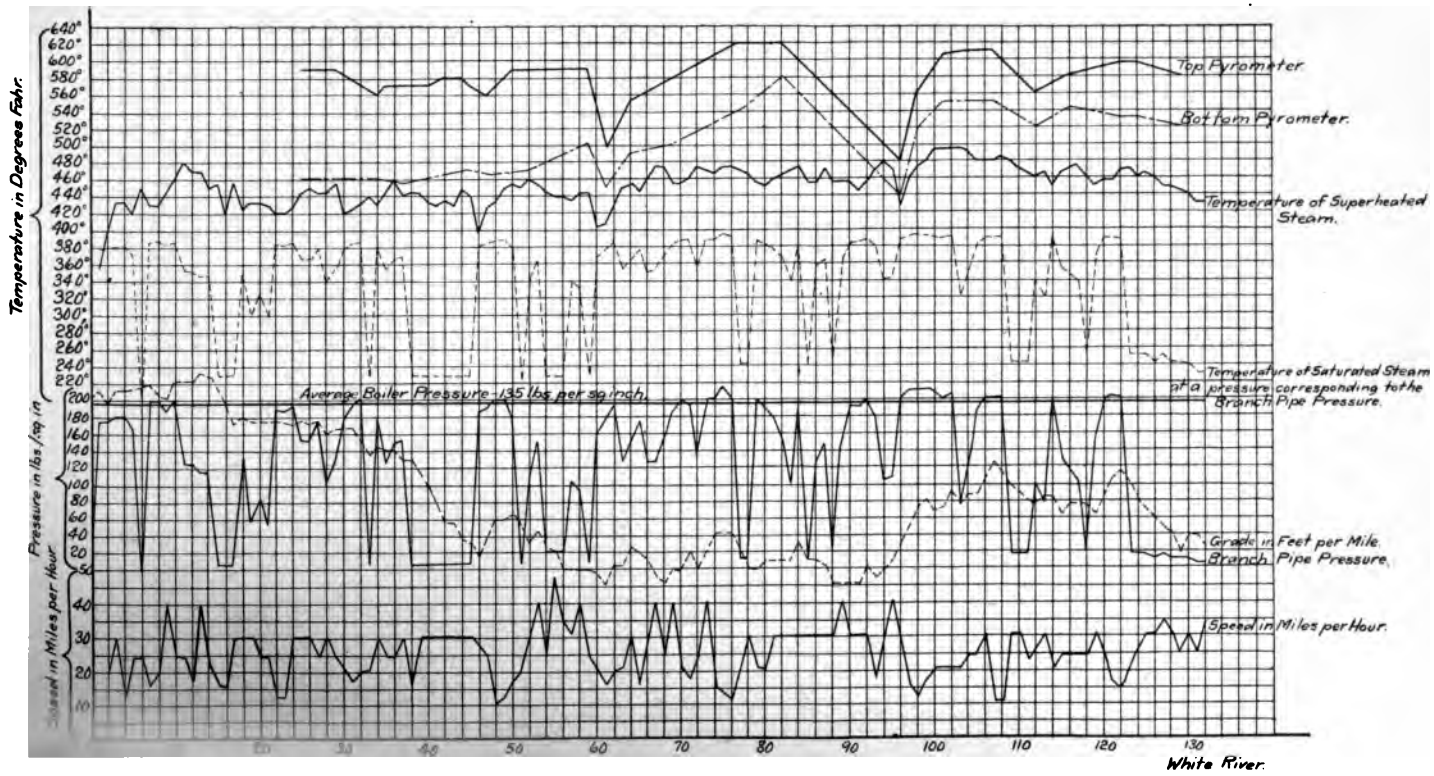
MR. WHYTE: Is that ten per cent distributed over the total coal bill, or over the amount of steam used in the cylinders?

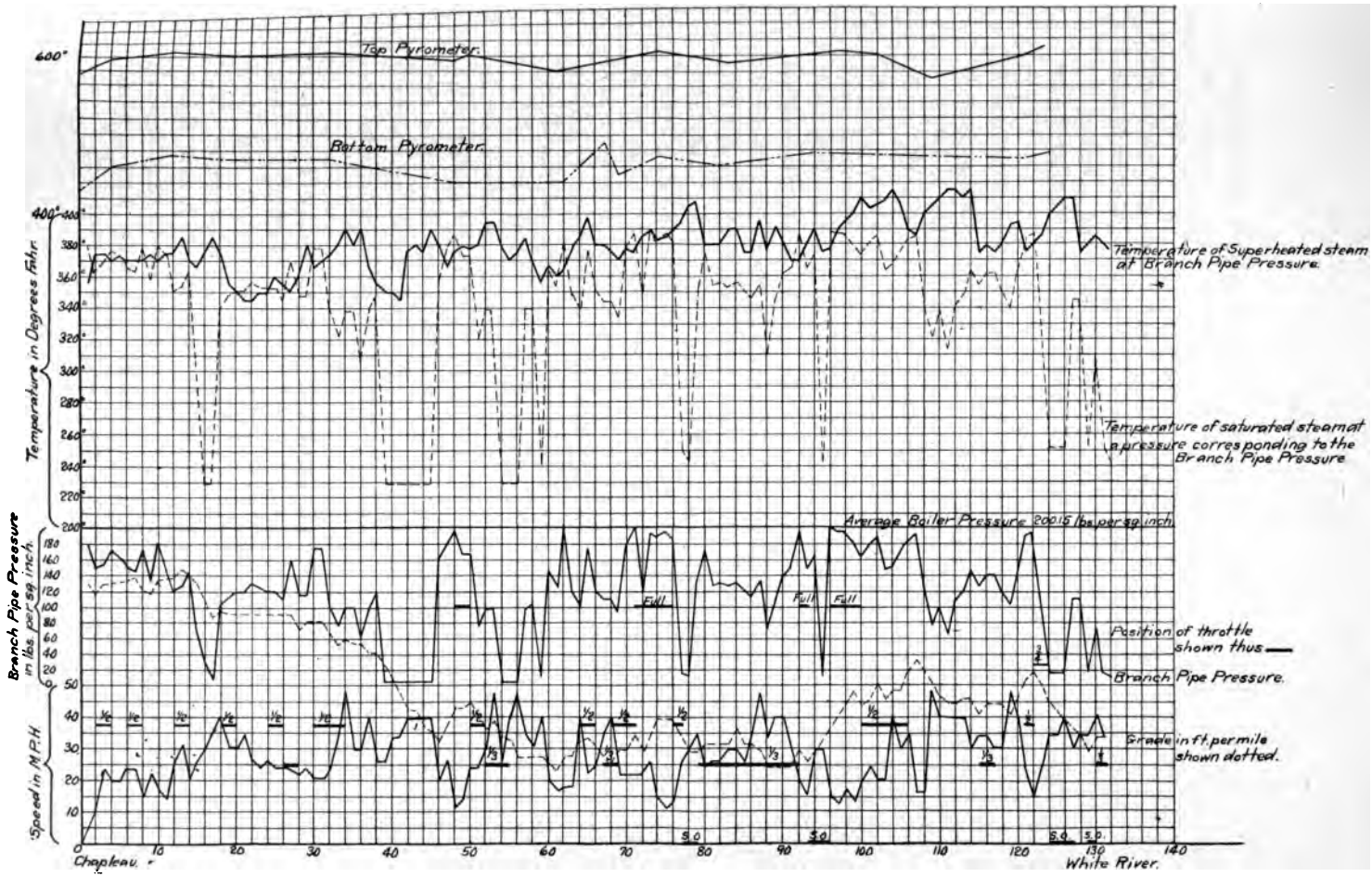
MR. VAUGHAN: These figures are coal-chute figures.

MR. WHYTE: How would you get twenty-one to twenty-five per cent economy in the compound over the simple — is that by using superheating?

MR. VAUGHAN: When you get a month's coal records in you may show twenty per cent economy in one month, and show no economy the next month; but if you show a coal economy in each succeeding month, running over a considerable period, and this economy runs from seven to twenty-one per cent, I think you are safe in taking ten per cent. Two engines of the same class will vary and coal figures are not always equal. One engine will make one thousand ton-miles on one hundred pounds of coal, and the next engine may require 130. It depends on many conditions and lots of things we can not take into account, such as the amount of way freight, switching, etc. If we get results on an entire class of engines as compared with the compound engine, month after month, we do not care much why it occurs. I like that result better than a test.

MR. ANGUS SINCLAIR: I have devoted a good deal of attention to superheated steam, and I am particularly familiar with the literature on the subject; and with that in view I wish to


Temperature in Degrees Fahr.
640°
620°
600°
580°
560°
540°
520°
500°
480°
460°
440°
420°
400°
380°
360°
340°
320°
300°
280°
260°
240°
220°
200
Top Pyrometer.
Bottom Pyrometer.
Temperature of Superheated Steam.
Temperature of Saturated Steam at a pressure corresponding to the Branch Pipe Pressure.
Average Boiler Pressure 135 lbs per sq inch.
Pressure in lbs / sq in
180
160
140
120
100
80
60
40
20
0
Grade in Feet per Mile.
Branch Pipe Pressure.
Speed in Miles per Hour
Speed in Miles per Hour
50
40
30
20
10
30
40
50
60
70
80
90
100
110
120
130
White River.


Top Pyrometer.
Bottom Pyrometer.
Temperature in Degrees Fahr.
Temperature of Superheated steam at Branch Pipe Pressure.
Temperature of saturated steam at pressure corresponding to the Branch Pipe Pressure
Branch Pipe Pressure in lbs. per sq. inch.
Average Boiler Pressure 200.5 lbs. per sq. inch.
Full
Position of throttle shown thus
Branch Pipe Pressure.
Speed in M.P.H.
Grade in ft. per mile shown dotted.
S.O.
Chapleau.
White River.

express my admiration for the excellent paper which Mr. Vaughan has presented to us and to speak about the great amount of research which it represents.

More than thirty years ago, when I was seagoing, I was connected several times with steamers that had superheaters in use. They were located in the uptake of the boilers and received the gases passing from the furnaces, so that they were subjected to a very considerable amount of heat.

The engineering world believed at the time that there was a great economy to result from the use of these superheaters; it seemed that a little extra expense made it possible to utilize a great amount of heat that otherwise passed through the stack. On ordinary reasoning, it seemed that great eeconomy would result from the use of the superheater; but somehow they gradually went out of use, and I think they are very little used to-day. In the case of the steamboats, it was like what sometimes happens with locomotives. If everything went on all right, economy would result, but if the superheater would give out, and something was wrong and a few hours lost at sea on a voyage, the expense involved by that delay was enough to overcome the advantages produced by superheating. That is the reason they have gone out of service. In fact, they were economical *per se,* but the fact that they were not economical in the end was that occasionally circumstances happened that depreciated their usefulness and a loss of economy resulted.

You will know of things of a similar nature happening in locomotive practice. Devices are introduced that promise great economy; and they seem to show economy at the start; but after they have been in use some time and people get careless about them, they fail to show their first favorable results and they are thrown aside.

There is a common expression that if you will paint a smokestack red and tell an engineer that it is going to effect an economy of ten per cent in fuel consumption, it will show an apparent economy of ten per cent; and that same thing applies to many things in locomotive service. If a man thinks that a thing will produce an economy he will do his best to work it out. It requires great discrimination to make sure you are getting economy from a thing that promises to save fuel.

One time I was invited to a test of a traction engine that was supplied with a superheater; and it seemed to me that was a very striking test. They had the means of passing the steam through the superheater or direct to the cylinders at will. They would start up with the steam, same boiler pressure and cut-off as with the ordinary saturated steam, and the motor would make about ten miles an hour. Then they would change to the superheated steam, run the steam through the superheater and immediately, without any other change, the motor would go up to fifteen or twenty miles an hour, almost doubling the speed. I never saw anything so impressive or so convincing. That motor was kept in service and was expected to do great things and effect a revolution in the application of steam to motor vehicles, yet within a few years it was abandoned and the report went out that it was no good; that it did not show any special economy. Of course, there is something to be explained about that — there is a carelessness in use, or there is a letting of the apparatus run down. Nothing will do well under persistent neglect. We are so familiar with the same thing in locomotive practice that we can easily understand how the deterioration of the apparatus will vitiate its usefulness. We have seen compound locomotives go into service that certainly gave an economy of twenty per cent, and after the engine was running for a year or two the economy would be in the opposite direction. It greatly depends on how the appliance is looked after, and I think, gentlemen, when superheaters come thoroughly into use you will be able to judge of their benefit and of their real value, and in my opinion you will find that the test of service is the real test to show whether you have a good thing or not.

MR. F. M. WHYTE: If, as Mr. Vaughan says, there is a saving on the total coal bill of ten per cent per year, and that saving is made during the time steam is used in the cylinder, there must be a very heavy percentage of saving in the steam used in the cylinders. Therefore, the demand on the fireman who is putting coal into the fire box is much less during the time that steam is used in the cylinder. The saving in the steam that is used in the cylinder must be about twenty-five per cent in order to produce a saving of ten per cent in the total coal bill. This looks to me like one of the best ways of assisting the fireman.

railways are worked similar to the English system, although our conditions range probably between the American conditions and those of England. We have very difficult working in consequence of our hilly country, and it is only very recently that our grades were reduced to four per cent, so you can understand that our operation is difficult. But there is one thing, we come next to our American cousins and friends in the weight of our engines. We have some very heavy engines, some very heavy ones when compared to the English type. That is, we have some 107 English tons freight engines, but our engines for passenger work are not over 88 to 90 tons.

My mission to America this time is to obtain twenty English types of engines built in America, a rather unique position for me, but it was thought advisable for me to come. I am general works manager for our railways, and as the work is somewhat strange, it was deemed advisable for me to come across; and I am pleased to say we are getting a very successful job of our engines at the Baldwin Locomotive Works.

Tenders were called for from all over the world; we had some from England, some from Germany and some from America. The American tenders were the most favorable as to price and time of delivery. It is just four months since I arrived in Philadelphia from Australia, and we tested the first one of them last Saturday and the second yesterday, so we are doing very well, and I expect to have our engines delivered on time. The Baldwin Locomotive Works undertook to build our twenty engines and to commence delivery in four months, completing delivery in ten months; and it is very evident that they are going to complete their agreement with ease.

I have listened to the discussion to-day with a great deal of interest, because our conditions are much the same as the conditions talked of here. There are some differences. You are using steel boxes in America — we use all copper, but many of the little experiences of the gentlemen present to-day are some of my own experiences had with copper.

I have now been connected with the locomotive branch of our railways some forty years; I have seen it from its inception, and I know we have had considerable difficulty. The last paper

value of the two classes of engines. In mentioning this, I do so because the members may understand that we did not take a downhill set of figures in one statement and compare that with an uphill set of figures in another statement, in order to arrive at the tonnage. We took the uphill statistics against the uphill statistics in one section, and the downhill statistics against the downhill statistics in the other section. Therefore, you can all see that these figures which have been presented by Mr. Vaughan are as accurately and uniformly based as possible.

With regard to the question of repairs, on the first engine we had some difficulty. We had to overhaul some features of it, but I would like to know any new device that has come upon the market which has not required some alteration. Our experience in that respect with the superheater is only repeating the experience which has applied to all apparatus which has been introduced, and it does not militate in any way against the superheater as it is now in use.

MR. WILLIAM FORSYTH: Perhaps Mr. Sauvage can tell us something about superheaters in France.

MR. EDOUARD SAUVAGE (Western Ry. of France): Gentlemen, unfortunately I can not say much about superheaters in France, because we are only just beginning to consider the subject. I can say, however, that because of what I have heard here to-day from Mr. Vaughan and others, I am more anxious to investigate the superheater and make tests than before. Mr. Vaughan has given me some very good data, and when I return home I intend to push my investigations regarding the superheater more vigorously because of the information you have given me.

MR. H. H. VAUGHAN: All I can say, in closing the discussion is, that at the end of this year we shall have 106 of the engines in service equipped with superheaters, so whether our judgment is good or bad, you can see that we think we are on the right track after the experience we have had. I do not see how we could give any figures other than those which are given in this report, that could be reliable. I do not think that any figures could be more reliable, by which I mean to say, that we have not taken test figures. I may also say that when we got the

forty engines equipped with the superheaters they were not favorites with our men at all. If anything, there was a tendency to dislike the engines. We had an exceptionally good class of ten-wheel compound engines on the division they were put on, and the men had come to like these compound engines very well. When we put on the consolidation engines with the superheaters and gave them eighty per cent tonnage instead of one hundred and fifty, there was a little prejudice and the engines commenced with the men somewhat prejudiced against them, but there is no question that the engines have fought their way into favor on the coal records. I have never seen, in my experience, any road that watches the coal as closely as we do. As Mr. Manchester states is the practice on the Milwaukee, our Superintendents and Master Mechanics get a statement of the pounds of coal per thousand ton-miles that the engine is running every trip. We run a bi-monthly performance sheet that is got out within a week after the end of each period, on coal used, and the statements are run over very closely. There is no question in the minds of our Master Mechanics on the division, and myself and Mr. Cross, I think, that we are getting as good or better results than we got out of the compound. That is, to my mind, a great benefit. As a motive power man I would like to get away from the compounds. They are all right in a way — they may save us coal, and we may know that as a business proposition we have got to go into the use of compounds, but take it through a winter's business and we have more trouble with a lot of compounds on the road than with the simples. There is no question about it. It does not show up much on the repair bill, but it is there all right. We had a perfect epidemic of troubles with the intercepting valves of our compounds last winter. If you can do away with that and give us an appliance which will produce as good economy, you will relieve us of all this trouble. I look on superheating as a means by which we can justify ourselves in not building compound engines, and that is quite an advantage.

MR. C. A. SELEY (C. R. I. & P.): I would ask one question, if it may be permitted at this time. Aside from the economy of the superheating question, it has appeared to me that by eliminating the water from the steam and using dry steam, we would

eliminate a large amount of the failures caused by water. I would like to ask if Mr. Vaughan has an opinion based on his experience that such accidents have been reduced by the use of the superheater?

MR. H. H. VAUGHAN: There are two classes of breakage from the water; the first case is where a man has an engine in the roundhouse and he does not bother about opening the cylinder cocks and goes off leaving the cylinders half full of water, and he breaks something. Superheating does not eradicate that, but it does give dry steam in the cylinder when an engine is working, and I think there is a considerable saving in the trouble which has in the past come from water. In engine 548, with the smoke box superheater, you can not get water into the cylinder. I believe when Mr. Cross tested the engine he ran it with the water up in the dome and was not able to get water in the cylinder, but that engine obtains more superheat than any of the others. Our engines with the superheater have been the most successful from the roundhouse standpoint, and this may have been caused by the elimination of water troubles. I intend, as quickly as possible to turn out some engines from 21-inch to 23-inch, and cut down the boiler pressure and see if we can not get as good results with 160 pounds as 200 pounds pressure. If we can do that we shall save enough on the boilers to pay for anything we have to do in connection with the superheaters.

THE SECRETARY: I am informed that we have with us Mr. H. B. Howe, Works Manager of the New South Wales Railways, Australia, and I would like to make a motion that the privileges of the floor be extended to Mr. Howe. (The motion was carried.)

THE PRESIDENT: I take pleasure in introducing Mr. H. B. Howe, Works Manager of the New South Wales Railways.

MR. H. B. HOWE: Mr. President and Gentlemen: I feel very highly honored indeed that an invitation has been extended to me to have possession of the floor for a few moments, and I also feel deeply gratified at having the pleasure of attending this convention.

As the President has told you, I come from Australia, from the antipodes, some fourteen thousand miles from here. Our

railways are worked similar to the English system, although our conditions range probably between the American conditions and those of England. We have very difficult working in consequence of our hilly country, and it is only very recently that our grades were reduced to four per cent, so you can understand that our operation is difficult. But there is one thing, we come next to our American cousins and friends in the weight of our engines. We have some very heavy engines, some very heavy ones when compared to the English type. That is, we have some 107 English tons freight engines, but our engines for passenger work are not over 88 to 90 tons.

My mission to America this time is to obtain twenty English types of engines built in America, a rather unique position for me, but it was thought advisable for me to come. I am general works manager for our railways, and as the work is somewhat strange, it was deemed advisable for me to come across; and I am pleased to say we are getting a very successful job of our engines at the Baldwin Locomotive Works.

Tenders were called for from all over the world; we had some from England, some from Germany and some from America. The American tenders were the most favorable as to price and time of delivery. It is just four months since I arrived in Philadelphia from Australia, and we tested the first one of them last Saturday and the second yesterday, so we are doing very well, and I expect to have our engines delivered on time. The Baldwin Locomotive Works undertook to build our twenty engines and to commence delivery in four months, completing delivery in ten months; and it is very evident that they are going to complete their agreement with ease.

I have listened to the discussion to-day with a great deal of interest, because our conditions are much the same as the conditions talked of here. There are some differences. You are using steel boxes in America — we use all copper, but many of the little experiences of the gentlemen present to-day are some of my own experiences had with copper.

I have now been connected with the locomotive branch of our railways some forty years; I have seen it from its inception, and I know we have had considerable difficulty. The last paper

that was presented to you by Mr. Vaughan was a most interesting one, and one which I consider every locomotive man should pay a great deal of attention to.

I was very pleased to hear Mr. Sinclair refer to marine work. I have had some experience in marine work and possibly a good deal of the failure is due to lack of attention; but, as I said before, the paper is one that every locomotive man should give particular attention to, because I think there is a great deal to be got out of it, and more than we can see at the present time.

I do not know that I should intrude any further on your generosity, but I thank you for the opportunity of making these few remarks to you, and particularly as I come from the other side of the world; I was almost going to say outside of civilization; but we are civilized out there, too. It is a big country, Australia, as big as the United States, and in a few years our railways will be as varied as in the United States, and we will then reap some advantage from that; but I must thank you again for your attention to the few remarks which I have been privileged to make.

Adjourned until Thursday morning.

THURSDAY'S SESSION.

President Peck called the meeting to order at 10 o'clock.

THE PRESIDENT: The Secretary has some announcements to make.

THE SECRETARY: Mr. President and Gentlemen: I have the following proposition for associate membership:

We hereby propose for associate membership Mr. Lawford H. Fry, Engineer of Tests of the Baldwin Locomotive Works.

H. F. BALL,
A. E. MITCHELL,
J. F. DEEMS.

Under the Constitution, this notice lies over until the next convention.

THE SECRETARY: I have the report of the Auditing Committee as follows:

To the Members of the American Railway Master Mechanics' Association:

Your auditing committee has examined the books and reports of the Secretary and Treasurer, and find the same to be correct.

A. E. MITCHELL,
W. H. OWENS,
F. M. WHYTE,
Auditing Committee.

THE SECRETARY: I have the following resolution:

WHEREAS, It is reported that Mr. R. H. Soule has, because of ill health, found it desirable to give up active business temporarily; and,

WHEREAS, Mr. Soule has been for many years an honored member and is a past President of this Association; be it

Resolved, That the Association through its Secretary expresses its regret that he is not present at this convention, and also expresses the hope that he will be speedily restored to health and comfort, and that he may for many years in the future enjoy the fruits of his conscientious and faithful efforts in the interests of others, including this Association.

THE PRESIDENT: Gentlemen, what is your pleasure regarding the resolution?

MR. J. F. WALSH (C. & O.): I would move you, Mr. Presi-

dent, that the resolution be adopted as the sense of this convention. (The resolution was unanimously adopted.)

THE SECRETARY: Mr. C. H. Cory, formerly Superintendent of Motive Power of the Cincinnati, Hamilton & Dayton Railroad Company, a member of the Association since 1876, having retired from active railroad service, your Executive Committee recommends that he be elected a life member. A motion is in order to carry the recommendation into effect.

MR. J. F. WALSH: I move, Mr. President, that the recommendation of the Executive Committee be adopted. (Motion carried.)

THE SECRETARY: Gentlemen, as you all know, the *Railroad Gazette* has published a dictionary called the " M. C. B. Dictionary." They publish that dictionary under the supervision of a committee of the Master Car Builders' Association, without any expense to that Association. They now wish to publish a dictionary for the Master Mechanics' Association, to be called the " Master Mechanics' Dictionary," and they have asked that this resolution be adopted:

Resolved, That the *Railroad Gazette* be and hereby is empowered to publish under the supervision of a committee of this Association an illustrated dictionary which shall give the proper names of each and every part used in the building of locomotives.

There will be no expense whatever to the Master Mechanics' Association for the publishing of the dictionary. The publishers of the *Railroad Gazette* simply wish to have the approval of the American Railway Master Mechanics' Association, and the appointment of a committee to supervise the publication of this dictionary, the same as has been done in the Master Car Builders' Association.

A motion to adopt the resolution is in order.

MR. C. A. SELEY (C. R. I. & P.): I move that the resolution, as presented by the Secretary, be adopted. (The resolution was adopted.)

THE SECRETARY: The President has named as a committee to supervise the publication of this dictionary the following gen-

tlemen: J. F. Deems (N. Y. C. & H. R. R. R.); A. W. Gibbs (Penn. R. R.); A. E. Mitchell (L. V. R. R.).

THE PRESIDENT: The first order of business this morning is the report of the Committee on Locomotive Driving and Truck Axles and Locomotive Forgings, of which committee Mr. F. H. Clark, Superintendent of Motive Power of the C. B. & Q. Railroad, is the chairman.

Mr. Clark presented the following report:

REPORT OF COMMITTEE ON LOCOMOTIVE DRIVING AND TRUCK AXLES AND LOCOMOTIVE FORGINGS.

To the Members:

Your committee appointed in 1902 to draw up specifications for locomotive driving and truck axles and locomotive forgings, with instructions to defer our final report until after the Washington meeting of the International Railway Congress, has carefully considered the recommendations and discussion of our meetings of 1903 and 1904, and now presents the amended specifications given below for your consideration and approval. Your committee has conferred with representatives of the American Society of Mechanical Engineers and with members of Committee "A" of the American Society for Testing Materials, and a compromise specification suggested which we believe will be satisfactory to each organization, except as noted below for this Association. This compromise specification involves a change in the reduction of area from 35 per cent, as originally recommended by this committee, to 25 per cent. It also involves the bending test covered in our last report, specifying a 1 by ½ inch test piece bent cold, 180°, over a bar 1 inch in diameter. This test is recommended by both the American Society of Mechanical Engineers and the American Society for Testing Materials. Your committee, however, feels that it is not desirable, as it is hardly possible to get a 1 by ½ inch test piece without drilling a larger hole than we would care to recommend, and we believe further that the bending test is not essential, but that the information that would be derived from such a test would be more satisfactorily covered by the requirements for elongation and reduction of area. If, however, the members of the Association feel that the bending test should stand we will not object to having that test included in the specifications, but would suggest in that case the desirability of making the test piece ½ inch square, instead of 1 by ½ inch in section.

We wish to again call attention to the manner of taking the test piece by means of the tools described in our progress reports of 1903 and 1904, and especially to the drill submitted by Mr. J. F. Kincaid, of the American Locomotive Company, in the discussion of the report of 1904; also

to the arguments in favor of the test piece taken by means of a holiow drill, which for convenience are restated below:

1. The physical test outlined is one which should insure proper hammer work.

2. It does not show the manufacturer which axle is to be selected for test.

3. The axle tested is not destroyed, but is available for use if it meets the requirements.

4. The test may be used in the purchase of small lots, most orders from railroad companies being for from six to ten axles.

5. The test does not require a discard and in no way adds to the cost of the axle.

6. It furnishes the manufacturer with a check of the work done in his plant.

7. The test is one largely used by the United States Government for forgings.

The members of your committee feel that these specifications shown below will insure good material, and recommend that the specifications be adopted and the committee discharged.

F. H. CLARK, Chairman,
J. E. SAGUE,
S. M. VAUCLAIN,
L. R. POMEROY,
F. W. LANE,
E. B. THOMPSON,

CHICAGO, ILL., June 7, 1905. *Committee.*

PROPOSED SPECIFICATION FOR LOCOMOTIVE DRIVING AND ENGINE TRUCK AXLES.

MATERIAL.

1. Open-hearth steel.

CHEMICAL REQUIREMENTS.

2. Phosphorus, not to exceed..... .05 per cent.
Sulphur, not to exceed..... .05 per cent.
Manganese, not to exceed..... .60 per cent.

PHYSICAL REQUIREMENTS.

3. Tensile strength — not less than 80,000 lbs. per square inch.
Elongation in two inches — not less than 20 per cent.
Reduction in area — not less than 25 per cent.

TESTS.

4. One test per melt will be required, the test specimen to be taken from either end of any axle with a hollow drill, half-way between the

center and the outside, the hole made by the drill to be not more than 2 inches in diameter nor more than 4½ inches deep. The standard turned test specimen, ½ inch in diameter and 2 inches gauge length, shall be used to determine the physical properties. (See Fig. 1.)

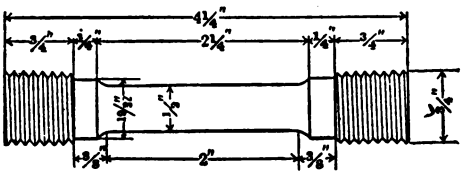


FIG. 1.

Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

5. Each axle must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than ⅜ inch high, and have order number plainly marked with white lead.

INSPECTION.

6. All axles must be free from seams, pipes and other defects, and must conform to drawings accompanying these specifications.

7. Axles must be rough-turned all over, with a flat-nosed tool, cut to exact length, have ends smoothly finished and centered with sixty-degree centers.

8. Axles failing to meet any of the above requirements, or which prove defective on machining, will be rejected.

PROPOSED SPECIFICATIONS FOR LOCOMOTIVE FORGINGS.

MATERIAL.

1. Open-hearth steel.

CHEMICAL REQUIREMENTS.

2. Phosphorus, not to exceed..... .05 per cent.
Sulphur, not to exceed..... .05 per cent.
Manganese, not to exceed..... .60 per cent.

PHYSICAL REQUIREMENTS.

3. Tensile strength — not less than 80,000 lbs. per square inch.
Elongation — not less than 20 per cent in two inches.
Reduction in area — not less than 25 per cent.

TESTS.

4. One test per melt will be required, the test specimen to be cut cold from the forging, or full-sized prolongation of same, parallel to the axis of the forging and half-way between the center and the outside.

5. The standard turned specimen, ½ inch in diameter and 2 inches gauge length, shall be used to determine the physical properties. (See Fig. 1.) Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

6. Each forging must have heat number and name of manufacturer plainly stamped on one end with figures not less than ⅜ inch high, and have order number plainly marked with white lead.

INSPECTION.

7. All forgings must conform to drawings which accompany these specifications, and be free from seams, pipes and other defects.

8. Any forgings failing to meet any of the above requirements, or which prove defective on machining, will be rejected.

PROPOSED SPECIFICATIONS FOR STEEL BLOOMS AND BILLETS FOR LOCOMOTIVE FORGINGS.

MATERIAL.

1. Open-hearth steel.

PHYSICAL REQUIREMENTS.

2. Grade "A":
   Tensile strength, 70,000 lbs. per square inch.
   Elongation in two inches, 20 per cent.

3. Grade "B":
   Tensile strength, 80,000 lbs. per square inch.
   Elongation in two inches, 17 per cent.

CHEMICAL ANALYSIS.

4. Grade "A":

Carbon	.25 to .40 per cent.
Phosphorus, not to exceed	.06 per cent.
Sulphur, not to exceed	.06 per cent.
Manganese, not to exceed	.60 per cent.

5. Grade "B":

Carbon	.35 to .50 per cent.
Phosphorus, not to exceed	.05 per cent.
Sulphur, not to exceed	.05 per cent.
Manganese, not to exceed	.60 per cent.

TESTS.

6. One test per melt will be required, the test specimen to be cut cold from the bloom, parallel to its axis and half-way between the center and the outside. The standard turned test specimen, ½ inch in diameter and 2 inches gauge length, shall be used to determine the physical properties. (See Fig. 1.) Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

7. Each bloom or billet must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than ⅜ inch, and have order number plainly marked with white lead.

INSPECTION.

8. Blooms and billets must be free from checks, pipes and surface defects. Any blooms or billets chipped to a depth greater than ½ inch will be rejected.

9. Any billet or bloom failing to meet the above requirements will be rejected and held subject to disposal by manufacturers.

10. Inspector to have the privilege of taking drillings from the center of the top bloom or billet of the ingot in order to determine the amount of segregation.

Grade "A" is intended for rod straps and miscellaneous forgings.

Grade "B" is intended for driving and truck axles, connecting rods, crank pins and guides.

MR. F. H. CLARK: I do not know that it will be necessary for me to read the specifications. We have three specifications: one for locomotive driving and engine truck axles; another for locomotive forgings and still another for steel blooms and billets for locomotive forgings. The committee does not regard these specifications as absolutely complete, but as a foundation, perhaps, for more detailed specifications, with the idea that railroad companies adopting them will probably want to add certain requirements to meet their conditions. For instance, it may be thought desirable by some railroad companies to allow a retest in case the test of the first axle shows defects. Some of the members in using these specifications may feel like specifying a discard of twenty-five per cent. While the committee thinks that is a good thing, it is rather of the opinion that most railroad companies are not in a position to see that they get the

twenty-five per cent discard, and consequently we prefer to leave that point, with others, to the discretion of railroad companies which may want to use the specifications.

THE PRESIDENT: The report is open for discussion. We shall be glad to hear from any member who desires to talk on this subject. It is a subject which has been in the hands of the committee for about three years.

MR. WILLIAM FORSYTH (*Railway Age*): I understand these specifications are similar to those which will be submitted to the American Society for Testing Materials at Atlantic City this month, at the meeting of that society to be held on the 29th, and that it will be there submitted to letter ballot. I think as a compromise specification it is in good shape for adoption and to be submitted to letter ballot by this Association, but I should like to see an addition or preface put before each of the specifications, to show that it is similar to those specifications which will have been adopted by the American Society for Testing Materials; and I would therefore move that each specification have a preface showing to this effect:

In essential features as to strength, chemical composition and excepting size of test specimen, these specifications are similar to those adopted by the American Society for Testing Materials, June, 1905.

I found that last year in preparing the specifications for boiler steel, that for commercial reasons it was a wise thing and a convenient one to place at the head of these specifications the fact that they agreed with some other specifications which were quite generally used throughout the country.

I would move that these specifications be submitted to letter ballot, and that they be prefaced by the matter indicated.

THE PRESIDENT: Gentlemen, you have heard the motion. Does any member wish to make any further remarks on the subject?

(The motion was seconded and adopted.)

THE PRESIDENT: The next business will be the report of Committee on Shrinkage Allowance for Tires, of which committee Mr. F. J. Cole, Mechanical Engineer, American Locomotive Works, is chairman.

Mr. Cole presented the report as follows:

REPORT OF COMMITTEE ON SHRINKAGE ALLOWANCE FOR TIRES.

The work assigned your committee was as follows: "To consider whether the present shrinkage allowance, 1-80 inch per foot, is sufficient for large-diameter wheels with cast-steel centers."

A circular of inquiry was printed and mailed to all members of the Association, reading as follows:

"*To the Members:*

"At the last convention the Committee on Standards recommended that the present shrinkage allowance for tires of 1-80 inch per foot be adopted for large-diameter wheels, but some question was raised as to whether this allowance was sufficient, and on motion the Executive Committee was instructed to appoint a committee to investigate the matter, and at a meeting held in Buffalo, July 25, such a committee was appointed to investigate and report at the next convention.

"At the convention of 1886 a report was adopted which recommended standard driving-wheel centers of 38 inches, 44 inches, 50 inches, 56 inches, 62 inches and 66 inches diameter. At the twenty-sixth annual convention the following sizes were adopted for standards for large driving wheels: 70 inches, 74 inches, 78 inches, 82 inches, 86 inches and 90 inches. The shrinkage allowance decided upon for these diameters was 1-80 of an inch per foot.

"Since that report was adopted the weights per axle have gradually been increased from about 40,000 pounds to 55,000 pounds, and in some cases 58,000 pounds.

"On heavy modern engines with steel centers of large diameter the general opinion is that these can not be worn as thin as formerly before they become loosened and require shimming and resetting. It is therefore customary on a few railroads to increase the shrinkage for such engine from 1-80 to 1-60 of an inch per foot in diameter.

"In order to obtain the necessary data and the practice of as many railroads as possible, will you kindly answer the following questions:

"1. Would you recommend a change in shrinkage of tires from the present allowance of 1-80 of an inch per foot?

"2. If so, what shrinkage would you recommend?

"3. If you recommend a change in shrinkage, should it be confined to large cast-steel centers?

"4. If so, what is the greatest diameter you would recommend for standard shrinkage of 1-80 and the smallest diameter for the increased shrinkage?

"5. Are you in favor of 1-80 shrinkage for 38-inch to 66-inch centers?

"6. Are you in favor of 1-60-inch shrinkage for 68-inch, 72-inch and 76-inch centers?

"7. Are you having much trouble from loose tires on large cast-steel wheel centers, with or without retaining rings?

"8. Are you having much trouble from loose tires on small cast-steel wheel centers?

"9. Are you having much trouble from loose tires on large cast-iron wheel centers?

"10. Are you having much trouble from loose tires on small cast-iron wheel centers?

"11. Are you having any trouble from loose tires when of full thickness? If not, at what thickness do they become loose?

"12. What cross-section of rim and spokes would you recommend for different diameters of cast-iron and cast-steel wheel centers?

"13. Cored vs. solid rims. Does the amount of bearing surface on rim influence the tightness of tires?"

Thirty-five replies were received representing about 19,000 locomotives, or thirty-nine per cent of the total number in the United States and Canada. A summary of the answers is as follows:

1. Twenty-four in favor of changing the shrinkage within certain limitations.

2. Eighteen in favor of 1-60 inch per foot shrinkage for large tires, but replies are conflicting, and some replies favor changing shrinkage for 56, 62 and 68 inches in diameter.

3. Eight replies in the affirmative.

4. The majority of replies indicate that a change in shrinkage should be made for wheel centers over 62 inches in diameter, but replies are conflicting, some recommending increased shrinkage for centers 56 inches and over.

5. Sixteen in the affirmative, but a number of railroads recommend lowering the limit from 66 inches to 60 inches and 62 inches.

6. Twenty replies in the affirmative.

7. Replies conflicting, but indications are that some trouble is being experienced with loose tires on large centers.

8. Twenty-four replies in the negative.

9. Replies conflicting. Large cast-iron centers not used on a number of roads. Eight roads replied that some trouble is experienced.

10. Twenty-five replies in the negative.

11. Twenty-seven replies in the negative. Replies indicate that loose tires occur when they are worn down to 2¼ inches and less in thickness.

12. Oval spokes with rim as wide as possible preferred.

13. Thirteen advised that cored rim is satisfactory. Nineteen think solid rim would be more satisfactory.

After carefully considering the subject and the number of locomotives represented by the different roads which have answered the circular, your

committee is of the opinion that a change in shrinkage allowance for large-diameter wheel centers would be advisable.

We would recommend that the present shrinkage of 1-80 inch per foot in diameter be retained for all centers of cast iron and cast steel less than 66 inches diameter, but 1-60 inch per foot in diameter be used for cast-steel and cast-iron centers 66 inches and over in diameter.

From the replies received, correspondence and discussion among the members of the committee, the consensus of opinion is that the design of wheel centers, especially those of cast steel and of large diameter, has much to do with the question of loose tires. Your committee, therefore, recommends that this question, including suggestions for preferred sections of spokes and rims, numbers of spokes, etc., would bear further investigation, which it might be desirable to refer to another committee.

One important point to be remembered in considering the question of cored vs. solid rims is that each pound of metal cut out of the rim opposite the counterbalance permits the center to be reduced two pounds, as the amount of metal has to be accounted for in the counterbalance. It is therefore probable that due consideration was not given to this side of the question in the replies received.

That tires are rolled out or stretched when worn to, say, about 2¼ inches in thickness has been confirmed by very careful measurements made of the tires after removal. The consensus of opinions and replies indicates that most of the difficulty experienced from loose tires occurs when they are worn to thicknesses varying from 1⅜ inches to 2¼ inches.

Loose tires are also caused by light cast-steel centers of insufficient section of spokes and rims to resist the shrinkage of the tire. This may also be occasioned by the distance between hubs being too great, requiring the spokes to be dished. In such cases, when the tire is shrunk on, the dish of the wheel center will be increased. The suggested standard distance between hubs on locomotives for standard gauge is 55 inches. This allows the use of straight spokes.

Broken tires are often caused by bad shimming when tires become loose and shims and liners are used, which only partially cover the circumference of wheel center and do not butt against one another, but leave spaces several inches in length. The tire is unsupported at these points and repeated transverse bending stresses are caused at each revolution of the wheel. Broken tires are again caused by too much shrinkage caused by improper gauging, and too much emphasis can not be placed upon the necessity of providing a first-class system of gauges, both for boring tires and turning off wheel centers. These should be referred to master gauges from time to time, to insure their accuracy.

A very large number of passenger locomotives in use have driving-wheel centers 72 inches in diameter. The Master Mechanics' standards are 70 inches, 74 inches, etc., and we would recommend including 72 inches diameter among the number of standard sizes. The extensive use of this size at the present time would warrant its recognition.

Your committee is of the opinion that the question of limit of thickness of tires for different purposes should be fully investigated and recommendations which would lead to standard limitations based on diameters, service and weight per wheel be recommended.

The Pennsylvania Railroad has used 1-64 of an inch per foot in diameter for a great many years for all sizes of wheel centers, both cast iron and steel.

The suggestions of the committee are summarized as follows:

Shrinkage 1-80th of an inch per foot in diameter for cast-iron and cast-steel centers less than 66 inches in diameter.

Shrinkage of 1-60th of an inch per foot in diameter for centers 66 inches and over in diameter.

Minimum thickness of tires should be established, due consideration being given to the diameter, service and weight per wheel.

Tire and wheel gauges should be of good design, heavy enough to resist bending and subject to frequent inspection to insure accuracy.

Seventy-two inches diameter of wheel center should be included in standard sizes.

Wheel center rims should preferably be uncut, but, if cut, slots should be machined out and closed with solid cast-iron liners driven in. No lead or white metal to be used.

F. J. COLE, Chairman,
J. E. MUHLFELD,
A. S. VOGT,
W. A. NETTLETON,

SCHENECTADY, N. Y., May 24, 1905. *Committee.*

MR. F. J. COLE: Mr. Muhlfeld wrote me a letter after this report was printed, in which he said: "I have not had time to go over this report carefully, but in looking over it in a general way I note the following:

"You refer in some cases to fifty-eight thousand pounds per axle, whereas I believe that these rates have reached as high as sixty-two thousand pounds.

"In the remarks no mention has been made of the use of Mansell retaining rings, or of similar devices, as safety appliances; in connection with the larger diameters of driver wheels, or in connection with truck wheels. This is a practice that I think should be referred to, and, in fact, recommended.

"Furthermore, no mention is made relative to the proper methods for applying liners when necessary in resetting tires, and no mention has been made of the heating effect of brake-shoe

action in connection with driver wheel and other tires. From our experience with various types of brake shoes and driver-brake gear, we are of the opinion that the use of cast steel is not desirable, as we have had quite a number of cases where tires have been badly cut and overheated from the use of cast-steel brake shoes, and, furthermore, we believe that when these shoes are used, and the tire runs toward the top of the shoe, instead of toward the bottom of the shoe, there is liability of the former tire being worn down to a proportionately smaller diameter than the latter. This has been especially noticeable on mountain grades, where high rates of speed and severe braking action when descending grades, tend to cause extreme friction and heating between the brake shoes and the tires."

THE PRESIDENT: Gentlemen, this interesting report is before you for discussion.

MR. F. F. GAINES (P. & R. Ry.): I don't understand the reason why the committee make a discrimination between certain diameters of wheel, increasing the shrinkage. I think the steel wheel center does require more shrinkage, and it is not limited to any particular diameter. You can go right on down to the 44-inch center. You have got to have more than $\frac{1.5}{0}''$ per foot of diameter shrinkage. For about three years past a shrinkage of $\frac{1.5}{8}''$ per foot diameter — that works out to .01875 per foot diameter — has been in use successfully. There has not been any trouble from it, and I believe it is absolutely necessary with the steel wheel center — it is in the elastic nature of the metal rather than anything else that requires this extra shrinkage. It will contract and it has a certain flexibility to it that your cast iron has not, and if it is true of any one diameter it is true of all, and it has been my experience that it is true of all.

Another point, I have found, that is a source of trouble in connection with tires, is the section of the tread. I think a great many of the steel wheel centers have had altogether too light a tread, that the tread has been too small and too light to resist the combined stress of shrinkage of tire and rough spots of the roadbed, and that an approximation of the cross section of tread similar to what we were using in years gone by for cast-iron wheels is a better practice than the lighter treads that have been used.

MR. E. W. PRATT (C. & N.-W. Ry.): Mr. President, I would like to ask the gentlemen who have just spoken whether in their experience it makes any difference as to whether the rims are solid or cut, with regard to the amount of shrinkage necessary.

MR. F. F. GAINES: I would say, Mr. President, that the wheels I have reference to were all cut wheels. I don't believe, especially in the larger steel wheels, that you can cast them solid, that is, successfully.

MR. PRATT: It seems to me, Mr. President, that is quite an important distinction. If the different members are talking, one about a cut rim, and another about a solid rim, and there is a difference with regard to loosening of tires, it would seem to me that that would have an important bearing upon the recommendations of the committee.

MR. A. E. MANCHESTER (C. M. & St. P.): Mr. President, our experience has been along the lines just referred to, that is, we are experiencing more trouble with tires loosening on steel centered wheels than on our cast-iron wheels. We use the split rim. In fact, in my efforts to have some of the steel manufacturers cast a solid rim, they have taken the position that they would only do so at the railroad company's risk, although I think there are manufacturers who are now undertaking to cast wheels that way. We have always tried to properly machine-cut and fill the space with a cast-iron block. But with all this there has been much more tendency for the tire to loosen on the steel wheel than on the cast iron. It appears to me that the rim of our steel wheel has been too light. I started nearly a year ago to put on a heavier rim and also to change the form of the rim, going back in the direction of our old cast wheel, having more of a brace and an arch to the rim. I have not had sufficient experience with the changed pattern to say definitely what the results will be, but I confidently believe that they will be better, and it seems to me that here has been one of the causes for the loosening of the wheel, that there was a spring taking place in the felloe that gradually worked on the filling block and wore it loose, and that has been one of the causes for the wheels loosening. This has been noticeable equally with wheels having the retaining rim, and without.

MR. WILLIAM MCINTOSH (C. R. R. N. J.): Mr. President, I think the attempt has been to make the steel wheel rather lighter than is justifiable, and thereby narrowing the rim to such an extent that it has not furnished the surface for the tire to bear on that is required. We have a number of engines that received the very light wheel that was so popular two or three years ago, and they caused us a lot of trouble. We are now widening the rim the whole width of the tire and hope to obtain better results. We have a certain class of engines that broke their cast-iron main centers. These were evidently lacking in strength. We substituted steel centers of exactly the same design and I have not noticed that we are encountering any trouble with loose tires on those wheels. I am very much of the opinion that the difficulty is more attributable to the light section of the steel wheel than it is to any difference between steel and cast iron. As far as the sectional wheel is concerned, I do not apprehend there need be any trouble with that, providing, as Mr. Manchester suggests, the slot is machined and a solid material is used for blocks.

MR. W. H. V. ROSING (Mo. Pac. Ry.): I do not think, Mr. President, that I have had any experience that would be of any interest to the meeting. We have had some difficulty with steel wheel centers, and found in shrinking on the tire that the wheel would dish slightly. We consequently concluded that the centers were too weak. The rims of our wheels are parted in molding, as is the usual practice. As yet I have not done anything more than to consider the subject, and I thought some of welding those sections together. I have not tried it yet, but propose to do it.

MR. A. E. MITCHELL (L. V. R. R.): Mr. President, my first experience with large wheel centers was on the Lehigh Valley R. R., and I found a very peculiar situation. We use a shrinkage of 1-64 inch for these large wheels, but we have found that the wheel center is gradually reducing in diameter, due no doubt to this shrinkage, and further, as we renew our tires we find the wheel center is less in diameter than when the tires were originally applied, and we can not maintain the original standard diameter of these wheel centers. This seems to indicate that the wheel center is too light in section, and we are investigating the

same points again after the tire had been shrunk on, with a shrinkage of 1-80 per foot, and with a parted wheel, with cast-iron filling blocks. After the tire was shrunk on, it was found that the rim was smaller in diameter, that the spokes had taken the form of a letter S, slightly, but nevertheless markedly, and that the dish of the wheel had been increased by 1-16 inch. Some tests which were made recently on the shrinking of cast-steel gears on extended wheel hubs 10 inches in diameter, showed that after the gearing had been shrunk on it would require 160 tons to remove the wheel from the axle, whereas, the wheel had been put on at thirty-two tons. The gearing was shrunk on with a difference in diameter between the gear and wheel hub of 1-100 inch for 10 inches. This will indicate what a shrinkage of about 1-80 inch per foot in diameter will mean, that is, what resistance it ought to offer if the wheel center is stiff enough to withstand the shrinkage without being deformed. Probably the rim should be increased in width, but the spokes should also be increased in thickness in the opposite direction to which the rim is increased.

MR. W. CROSS (Can. Pac. Ry.): Mr President, the last arguments have been based upon the compressibility of the wheel center. That is a very difficult proposition to put before practical men. While all tests and measurements must be admitted to have their place, still there is something else that is required to look into in recognition of the fact that a wheel center will actually lose its diameter, and the fact that this can be done will upset all calculations and ideas in regard to what the shrinkage ought to be in a tire; and if that fact has to be admitted, that you can reduce the diameter of a wheel center by compressibility, then you must admit that whatever limit you set for tire shrinkage, let it be 1-100 or 1-80 or 1-60, whatever it may be, you reach the limit of your tire shrinkage the moment you admit that your wheel center will shrink. Therefore, 1-100 inch to the foot is as good as the best that you can set out. It strikes me that the whole subject comes down to three points; first, the securing of the tire on the wheel; second, the parting of the wheel center to admit of shrinkage of the wheel itself in the manufacture, and, third, the material in the center. The experience gained, seems to me to be undoubted that the steel center has proved more effective in loosening tires

MR. E. A. MILLER (N. Y. C. & St. L. Ry.): Mr. President, our experience has been that we have had more trouble from loose tires on the steel wheel center than on the cast-iron wheel center on the same class of engines and the same diameter of wheel centers. We attributed that to the narrow wheel rim and also to the lighter structure of the wheel center. I am satisfied that the cross sections of the centers have been made too narrow, and that we will have to widen them to at least as much as the cast iron. In fact, I am satisfied that the steel center should be widened out to practically the full width of the tire. The driver brakes are a very important factor in the loosening up of tires, and a tire that would run formerly without giving any trouble will loosen up under the using of the driver brakes, and in order to overcome as far as possible the loosening of tires from the friction of the driver brakes, we should have as wide a cross section for tire bearing as we can use.

MR. W. G. MENZEL (Wis. Cent. Ry.): We had some trouble with loose tires and last winter had a tire break that was worn down to about two inches. I happened to be passing through the shop while a man was calipering the wheel for a new tire and found that the face of the rim was tapered. It was smaller on the inside edge of wheel. The calipers did not show any change in the outside edge of the wheel centers from the original diameter of the wheel, but the inside had become smaller, showing that there was a compression in the rim. The rim was about 1⅛ inches narrower than the tire. I think it is a very important point, that we get the rim the full width of the tire, and also that it be braced by the spokes, that is, widen the spokes to the same width as the rim.

MR. F. M. WHYTE (N. Y. C. & H. R. R. R.): Mr. Chairman, I think it was quite natural at the time when cast-steel centers were being considered, to try to offset the difference in price by a difference in weight, and no doubt the centers were made too light. That has been demonstrated in one or two cases by measuring the wheel center before the tire was shrunk on and measuring the bore of the tire and the diameter of the wheel, and placing marks upon the wheel, both upon the spokes and upon the rim, and measuring the dish of the wheel as well, and measuring the

same points again after the tire had been shrunk on, with a shrinkage of 1-80 per foot, and with a parted wheel, with cast-iron filling blocks. After the tire was shrunk on, it was found that the rim was smaller in diameter, that the spokes had taken the form of a letter S, slightly, but nevertheless markedly, and that the dish of the wheel had been increased by 1-16 inch. Some tests which were made recently on the shrinking of cast-steel gears on extended wheel hubs 10 inches in diameter, showed that after the gearing had been shrunk on it would require 160 tons to remove the wheel from the axle, whereas, the wheel had been put on at thirty-two tons. The gearing was shrunk on with a difference in diameter between the gear and wheel hub of 1-100 inch for 10 inches. This will indicate what a shrinkage of about 1-80 inch per foot in diameter will mean, that is, what resistance it ought to offer if the wheel center is stiff enough to withstand the shrinkage without being deformed. Probably the rim should be increased in width, but the spokes should also be increased in thickness in the opposite direction to which the rim is increased.

MR. W. CROSS (Can. Pac. Ry.): Mr President, the last arguments have been based upon the compressibility of the wheel center. That is a very difficult proposition to put before practical men. While all tests and measurements must be admitted to have their place, still there is something else that is required to look into in recognition of the fact that a wheel center will actually lose its diameter, and the fact that this can be done will upset all calculations and ideas in regard to what the shrinkage ought to be in a tire; and if that fact has to be admitted, that you can reduce the diameter of a wheel center by compressibility, then you must admit that whatever limit you set for tire shrinkage, let it be 1-100 or 1-80 or 1-60, whatever it may be, you reach the limit of your tire shrinkage the moment you admit that your wheel center will shrink. Therefore, 1-100 inch to the foot is as good as the best that you can set out. It strikes me that the whole subject comes down to three points; first, the securing of the tire on the wheel; second, the parting of the wheel center to admit of shrinkage of the wheel itself in the manufacture, and, third, the material in the center. The experience gained, seems to me to be undoubted that the steel center has proved more effective in loosening tires

than the old centers that formerly existed. In our first experience, we took the old wrought-iron centers, then the cast iron, and now the steel centers, and we ask ourselves why this has come in. It would be a very simple illustration where a man wants to draw out a piece of cold iron under the hammer and employed a wooden anvil. He would get little effect there. But put it on a steel anvil and he immediately gets the effect the moment he hits his iron. Now, our tires, the moment they are applied, are subject to an elongation process, in other words, lamination. Lamination takes effect immediately when the engine or the car gets into operation. If in considering the subject of the cast iron and the steel you allow that in one case you have a hard metal comparatively and in the other a softer metal, you allow very largely for the fact that you have a greater elongation on the steel center than on the cast-iron center, and it seems to me that in this you have a simple explanation as to why tires are loosening more upon the steel centers than they did on the cast iron. This will, of course, answer very largely the fact that centers have been found tapered or out of true on the circle after tires have been removed. In my own experience with a wrought-iron center I invariably found that the rim was rounded. The fact of this was that the tire got worn down with the pressure toward the center, simply widened the top of the tire, causing the tire itself to get hollow and the wheel to correspond. There really was no shrinkage in the diameter of the center, but there was a difference in form. Now, while we may admit that a tapered center may be obtained in the same way, the suspicion will also always come up that the man that made it was in fault and that no natural cause has created this, because in our universal practice, of all the members here, we have seen tires all over our systems exchanged on wheels. Now, if you had a suspicion at all that your wheel centers were changing by the natural action of the engine upon the tire, you would not do this. Yet, we are all doing it; we make that a part of our system.

In regard to the parting of the rim of the wheel center, many years ago on the Canadian Pacific Railway we adopted a method of inserting in the wheel center a core which reduced the amount of metal in the rim. The idea was this, that if the contraction of the arm was so great that something had to give way, we weak-

ened that rim in such a way that the parting would come right there where now the open parting is made. The tire is simply shrunk on to that. I think we overcome all difficulty, both with the filling of the rim and also the difficulty of shrinkage, when manufacturing these centers. I give this as the experience which we gained. It seems to me that in connection with this subject it is well worth consideration as to what limit tires ought to wear down to and then be remeasured and tightened up for their final wearing. This one idea brings us back to another, as to whether, if our passenger trains have to run so fast and run over such a variety of country, tires are subject to straining by the nature of the land they run upon, by the filling in the roadbed; and it is our duty as mechanics to consider whether in looking after these technical points we are filling the bill as we should, and as we can. On the Grand Trunk they have adopted for many years a retaining ring, and it seems to me that this subject, to be fully treated and reported upon, should include this proposition, as to whether we are filling the bill by submitting to the public a tire which we admit is liable to make an accident at any time.

MR. DEEMS: Mr. President, it seems to me from the discussion we have had here that to appoint a committee simply to take up the question of tire shrinkage, does not cover the ground to start out with. If we admit the rules laid down by the Association some years ago for cast-iron wheels were right, then, when we come to use the same rules for steel centers, and find that we do not get the results we want, it is a little surprising that we blame it on the tire. I think we should have gone to the wheel center in the first place. I think there is little or no doubt that the wheel centers we have been using have been too light, and as the speaker has just said, I think if you will look at the rim of one of the steel wheel centers that have been running a long while, you will find the centers rounded on the surface, and you will find the wear on the tire, the impression of the wheel, will be at the extreme outer edge and as indicated by the experiments Mr. Whyte has quoted. It seems to me that the subject should either be referred back to this same committee or to another committee, for further consideration, taking into account the whole question of the design of wheel centers, including that of the parted rim or solid rim; and

in order to dispose of the question, I move that the subject be referred back to the committee, to be considered with reference to the wheel centers.

MR. C. E. FULLER (C. & A. Ry.): I would suggest that the committee be instructed to take into consideration the section of the spoke and rim of the present steel wheel center in use before their recommendation is accepted to increase the shrinkage of tires. We believe, if their recommendation is accepted to increase the shrinkage of the tires on our present steel wheel centers that are now in use, that we will not obtain the desired results. We have found by investigation where we increase the shrinkage of the tires on steel wheel centers with the light spokes and rims that are now in use, that the spokes have been dished, and in some cases formed the shape of the letter S, and by increasing the shrinkage this bending of the spoke naturally increases. Before the question of the shrinkage of tires on steel wheel centers is settled, we would suggest that this committee redesign the shape and size of the spokes, as well as the rim of the wheel, recommending a shape and size of rim and spoke that will withstand the shrinkage without the spokes becoming distorted.

F. F. GAINES (P. & R. Ry.): If Mr. Deems will accept it I would like to make an amendment to his motion in connection with shrinkage and design of the wheel itself, that the subject of best method of securing the tires to the large wheel centers be also considered, that is, whether retaining rings or shoulders on tires should be used.

MR. DEEMS: I will gladly accept that. I consider that a part of the work.

MR. A. E. MANCHESTER (C. M. & St. P. Ry.): I would like to supplement what I have already said in connection with this subject — and from the remarks of the gentlemen, it appears that there is a general feeling that our wheel centers are too light. This I believe is demonstrated in some of the matters in relation to the breakage of tires. With the old cast-iron center — and I admit it was well supported, because I never have had any occasion to think otherwise — a broken tire, if it broke in detail, as tires frequently do, you could most always trace the rupture from

the inside of the tire toward the circumference. Within the last year on the large wheel centers I have found a great many cases in which the rupture started at the extreme top of the flange and went down in detail until it involved the tire; and I am thoroughly convinced that this is the way that our large tires are breaking. I have found them in all stages of rupture, from just a mere speck starting on the top of flange until it involved the whole flange, and in some cases down into the solid part of the tire.

Another thing that has come to my observation in connection with this subject is, that during the extreme cold weather of last winter we had a number of cases of broken tire and broken rails. It is the rails that I wish to refer to especially. An examination was made to determine if there were any visible defects in any of the engines that were operating over a particular division in which this seemed to occur, and the usual tests were made by an examination of the surface of the tire to see if there were any worn flat spots or anything of that kind to account for the breakage. The broken rails seemed to follow two engines. It narrowed down to the investigation of these two engines very carefully. Experts were sent to ride these engines to see if there was anything about the riding of them that would bring about this condition, but their reports were that there was nothing wrong with the engines; they were riding perfectly smooth. Now, mind you, the contour of the tire, the face of the tire, showed no imperfection; the riding of the engine showed no imperfection, but it was so apparent that these two engines were doing the mischief that we made a gauge, gauging from the center of the wheel to the circumference of the tire, and there we found our wheel out of radius 5-32 inch. There on that big wheel center nobody could discover that the engine was riding improperly at all from this eccentricity, and that is what it was, it was a regular eccentricity, but there was enough of that condition no doubt to cause the breakage of the rails, because with the removal of the conditions there was no more breakage of the rails.

MR. W. E. SYMONS (K. C. So. Ry.): I have observed in removing tire from a steel wheel center, that this oval or concave condition of the surface of the wheel center or rim existed at two

points more prominently than anywhere else and directly opposite, being on a line through center of crank pin and counterbalance section. At the other point the spokes of the wheel center had assumed the shape referred to by the former speakers, of a double S, indicating very clearly to my mind that the face of the wheel center or rim had, in yielding to the shrinkage of the tire, been formed into an oval shape at the rigid points, and at the two opposite points the spoke having assumed this double S shape, allowed the wheel center to suffer a distortion from a true circle, and as has been remarked by Mr. Deems, should be redesigned, especially the cast-steel wheel center, and I think the committee should give this matter especial attention in their consideration, in order to prevent the possibility of the wheels assuming an oval shape as the result of tire shrinkage.

MR. PRATT: Has Mr. Deems' motion been seconded?

THE PRESIDENT: The motion of Mr. Deems was seconded, and the Secretary will read the motion which is now before the house.

THE SECRETARY: Mr. Deems' motion was that this subject be referred back to the committee for further consideration, taking into account the whole question of design of wheel center, including parted rim or solid rim, also the width of same. Mr. Fuller suggests taking into consideration the section of the spoke as well as the section of the rim. Mr. Gaines suggests that the subject of securing tires to the large wheel centers should also be considered.

These suggestions were agreed to by Mr. Deems.

The motion of Mr. Deems, as amended, was duly adopted.

THE PRESIDENT: We will now take up the report of the committee on Locomotive Terminal Facilities and Method of Heating and Ventilating Roundhouses, of which Mr. D. R. MacBain, Master Mechanic of the Michigan Central Railroad, is chairman.

Mr. MacBain presented the report as follows:

REPORT OF COMMITTEE ON LOCOMOTIVE TERMINAL FACILITIES AND METHOD OF HEATING AND VENTILATING ROUNDHOUSES.

To the Members:

Your committee on the subject—

A—"What can be done to reduce locomotive terminals to the basis of a machine for treating and handling of engines apart from the matter of housing, the object being the prompt handling of power, greater efficiency in service and less detention at terminals, while affording more time and better facilities for care and repair of engines;

B—"To investigate the best methods of heating and ventilating roundhouses,"

Begs leave to report as follows:

Owing to difficulties over which your chairman has had no control, the committee has never met to discuss the questions in hand, and therefore, any great diversity of opinion in regard to the matters under discussion has not been available for consideration. However, as the subject "A" is one with which anyone who has handled power should be pretty well acquainted, especially after a few winters in the Northern countries, we will endeavor to give an idea of the requirements of the case as we see it. Viewing the matter from a business standpoint it would appear that the question of cost is one that should not be overlooked, and in compiling our report will try to keep this in mind. Of course, location is a very important factor in most instances, and considering the fact that any change that would need to be made under the above circumstances would have to be fitted to the conditions existing in the matter of location, space, drainage, etc., we have taken, as an example in one instance, an old plant, made over so to speak, from a very awkwardly situated and poorly equipped institution to one that is, in our opinion, about up to date, and another that is not as necessarily affected by the conditions named as the other, and either of which, we feel quite sure, will not prove a disappointment if put into use.

Plan No. 1, which is shown in attached diagram, will be offered as the "old plant made over." It will be noted that the space available, at the time the change was made, was very limited, and the engineering department had to cut to fit conditions. A description of the plan is as follows:

The coming-in track, upon which all engines are left by the road crew.

An elevator track, stubbed at one end and with sufficient rise for its whole length in the clear, to enable elevator men to move cars on or off the hoppers at will by the manipulation of the hand brakes and perhaps a little start with a pinch bar. Power is also provided for the movement of cars on and off the hopper, but is seldom used.

Clinker-pit tracks Nos. 1 and 2, both of which run to the turntable direct, and the depressed track for cinder cars, the approach of which is laid on a two per cent grade.

The coal elevator, which is the latest improved type of the Chicago Link Belt Company, and has a capacity of 500 tons.

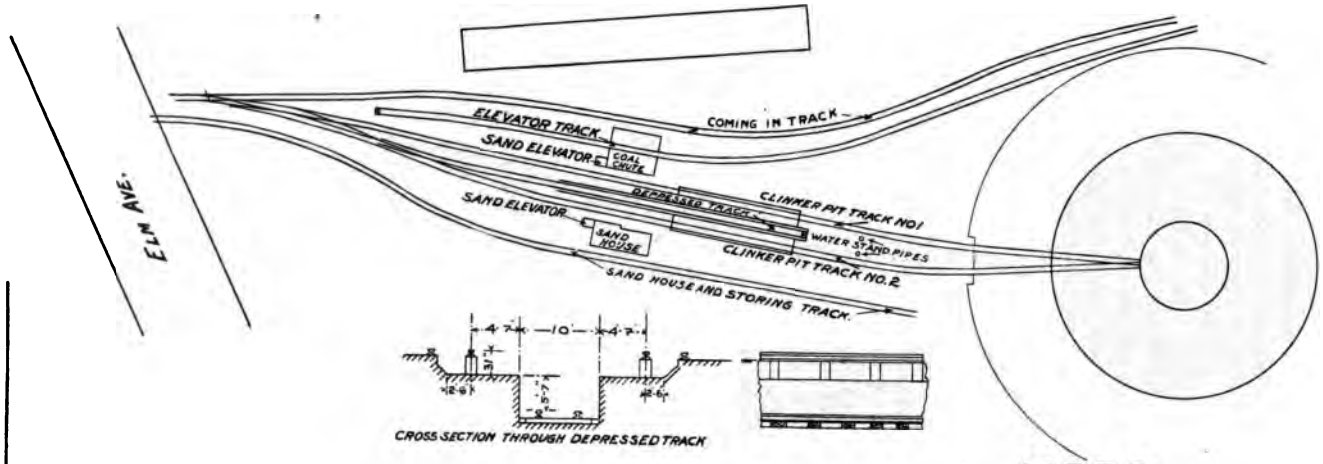
The sanding boxes, which are placed as follows, one on the corner of the coal elevator adjoining the clinker-pit track No. 1, and another adjoining clinker-pit track No. 2 on the corner of the sandhouse proper. The sanding of engine is done by means of drop pipes which are handled by hostlers, the time required for filling the largest boxes being about fifteen seconds. The sandhouse is equipped with three stove dryers, and sand is elevated into sanding boxes by means of compressed air. Storage is provided for about twelve carloads of wet sand, which is unloaded from cars placed on sandhouse and storing track. The sanding box on clinker-pit track No. 2, on sandhouse proper, is large, having a capacity of about ten cubic yards, and out of this box sand needed for outside points is loaded into cars placed on sandhouse track, by means of a drop spout or chute. Nine or ten yards of sand in this way can be loaded in a few moments.

Each of the clinker-pit tracks is provided with a 10-inch water column and tenders are filled very quickly, the filling of tenders being the last operation before engines are put on the turntable. This is not as the plant was planned, it being intended that the knocking out of the fire should be the last operation, but conditions of space made that impracticable.

The cross-section of the clinker-pit track shows the general plan, the inner rail (100 pounds per yard) being supported on cast-iron piers which are jacketed with No. 10 iron, the remaining space on the inside filled with concrete, tie rods at 10-foot spaces being provided along open space of clinkering tracks to prevent possibility of rails spreading. The clinker pits and depressed track are of solid concrete and good drainage is provided. Two hydrants are provided on each clinkering track for wetting cinders and a steam pipe is provided for thawing out ash pans and grates when such is needed.

In preparing this plan it was sought to make it as near a "machine" as possible and the results obtained during the past winter were not disappointing in that respect.

Engines arriving off the road are left on the "coming-in track," and when they come in in quick succession, as is the rule in the winter or during any season of heavy traffic, no attempt is made to coal all of them on the north side of the elevator, hostlers usually alternating, that is, one is coaled on the north side and the next on the south side, or if necessary, several engines are taken off the coming-in track at once and coaled up on clinker-pit track No. 1. In this way it will be observed that when necessary to get hold of, say the sixth engine in line, the first five engines can be taken at once on to clinker-pit track No. 1, and the engine that is most desired can then be coaled on the coming-in track, after which it can be taken



M.C.R.R.
LAY OUT OF COAL CHUTE,
CINDER PIT, AND SAND HOUSE TRACKS.
AT Jackson Junct.

PLAN 1.

around on to clinker-pit track No. 2, sanded, clinkered, watered and housed, in from fifteen to twenty-five minutes from the time of its arrival.

All engines when going out for trains use a track provided for that purpose alone and in no way interfere with the putting in of engines, except when on the table. The outgoing track is also provided with a water column to serve engines leaving the house.

The regular equipment of men is six hostlers and six clinker-pit men, three of each for the day and night shifts respectively, and 100 engines are handled in twenty-four hours without difficulty or rush.

In addition to the duty of clinkering, the clinker-pit men also attend the switches at west end, unload the wet sand, run the dryers, elevate sand to sanding boxes, attend to water columns and shovel the cinders on to the cars on the depressed track.

The equipment of men for the coal elevator is one elevator man, one dumper and one loader for each of the day and night shifts, or seven men all told, including the fuel foreman.

At the present time coal is being handled from the car to the tender for 3 7-10 cents per ton, and this could be reduced considerably if enough coal was used to keep the help around the elevators busily employed.

Your chairman considers this plant as approaching closely to the "machine" idea and of sufficient capacity to handle 200 engines per day of twenty-four hours without difficulty.

Photographic prints are shown which will illustrate the general appearance of the plant.

Print No. 1 shows view looking east and the layout of the incoming tracks and clinker-pit tracks. The coal chute, of which mention is made heretofore in this paper, is shown in the center of the picture with the incoming track to the left. To the right of the coal chute can be seen the two ingoing tracks which lead over the clinker pits and also the lead leading to the depressed cinder track between the clinker pits. It will be noted from this layout that engines can be coaled on the incoming track at the left of the chute and on the ingoing track at the right, as the case may require.

At the extreme left hand of the picture can be seen the old coal chute with track laying along side of it which is used for storage purposes and also for emergency use in coaling in the old chutes in case of any accident disabling the new one.

Print No. 2 shows a view looking west from the point at which the water columns are located.

Print No. 3, taken at the point where depressed cinder track commences, shows a more detailed view of sand elevator, illustrating an engine taking sand from elevator on the southwest corner of coal chute, and also car being filled with dry sand from the elevator on the right-hand side.

Print No. 4 shows a more detailed view of the clinker-pit construction and illustrates the gondola cars placed in the depressed track between the two pits to receive cinders.

Plan No. 2, as shown on the attached diagram, provides, as will be noted, a set of tracks upon which incoming engines can be spotted by the road crew, where they are left until the hostlers take them out for coaling, clinkering and housing. The object of the spot tracks is to permit of the last engine to be the first one housed, if such is desired. This plan, it will be noted, requires a lot of space, longitudinally at least, and perhaps could not be utilized at all points on this account. We quote in full the recommendations of Mr. W. R. McKeen, Jr., the designer of this plan:

"Railroads at large are just commencing to realize the importance and necessity of adequate roundhouse facilities. Efficient results from roundhouses have always been demanded, but necessary facilities have, as a rule, been sadly neglected. Following are some of the important facilities a roundhouse should have:

"1. What is known in the yard language as a 'spot'—a system of tracks connected to the inbound track in the yard, also connected to the main coal track leading to the roundhouse table; this system of tracks to be so designed as to enable at least ten engines to be delivered by inbound engine crews, any one of which can be moved to coal chute in preference to the other nine at any time.

"2. An outbound 'spot' track and a water crane, so that outbound engines could take a full tank of water just before leaving; also water cranes so that inbound trains could take water immediately after taking coal.

"3. A double cinder pit and means of wetting down and cleaning ash pans economically.

"4. Method of loading cinders into the ordinary steel car equipment by means of conveyors.

"5. Turntable not less than 85 feet with (preferably) an electric motor as power for handling same.

"6. Door with at least thirty-five per cent glass for lighting purposes; also locks at top and bottom and posts so that same could be locked open as well as locked shut.

"7. Smoke-jacks so arranged that engines could be moved a quarter of a turn and equipped with suction ventilators so that the harder the wind the stronger the up draft.

"8. A system of ventilators on top of the roundhouse for catching the steam and other waste products from a locomotive.

"9. Water pipes, air pipes, blow-off pipes, steam pipes and a good-sized steam supply pipe and taps for these for each pit.

"10. A permanent, sanitary, dry floor; not a gravel or cinder floor, but a concrete foundation with wooden blocks set on edge, filled in between with tar and cement, and so fitted in as to drain any water into the pits.

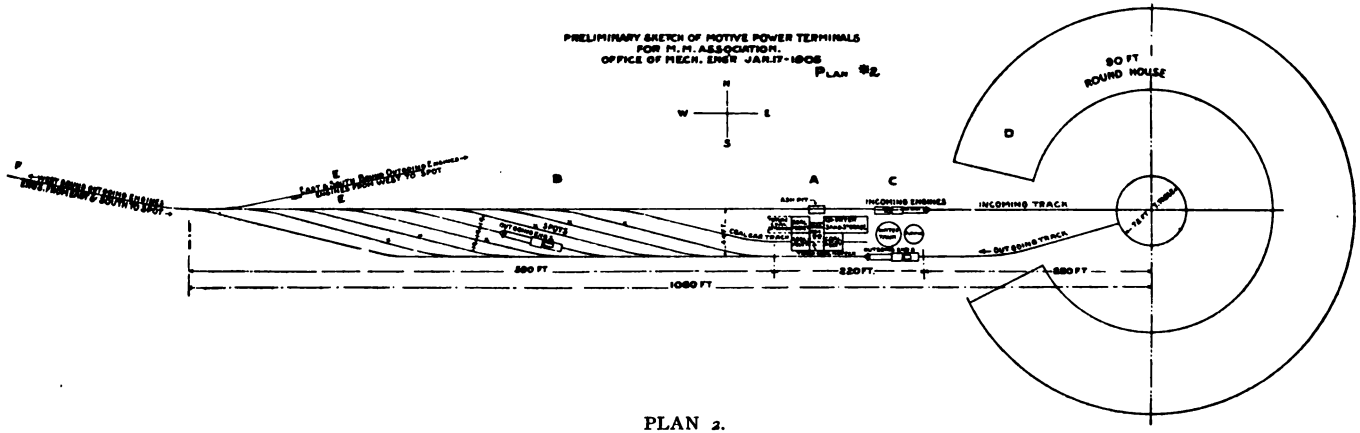
"11. A toolroom for the care of all general roundhouse tools.

PRINT No. 1.

PRINT No. 2.

PRINT No. 3.

PRINT No. 4.


PRELIMINARY SKETCH OF MOTIVE POWER TERMINALS
FOR M. M. ASSOCIATION.
OFFICE OF MECH. ENGR JAN. 17-1905
PLAN #2.
N
W
E
S
90 FT
ROUND HOUSE
D
E
B
A
C
INCOMING TRACK
OUT GOING TRACK
880 FT
220 FT.
880 FT
1080 FT

PLAN 2.

"12. A washroom for engine crews, lockers for their extra clothing, etc.

"13. Centrally located office and telephone facilities for the foreman.

"14. The low, flat roof of roundhouses is to be discouraged on account of the drippings in cold weather, and the impossibility of properly ventilating same."

The objections to plan No. 2, as your chairman sees them, are as follows:

First: Too many switches to look after and too much switch cleaning for the engineering department to attend to at times, when, owing to snow storms and extreme temperature, the limited number of men usually available for such purposes is kept busy keeping yard tracks open for operation.

Second: A switchman would necessarily have to be provided to attend "spot" switches.

Third: Conveyors for loading cinders are rather expensive, often out of order when most needed, and we believe unnecessary; the depressed track for cinder loading being free from breakdowns and always in shape to use. Modern steel cars are not, in our opinion, suitable for cinder work, inasmuch as the bottom dumps provide a *very* poor means of distributing cinders along the right of way for ballast, for which purpose, in most cases, they are used.

Fourth: The coal elevator and sandhouse should not, in our opinion, be as closely adjacent as this plan provides.

Fifth: The cinder, or clinker pit, should be located on the house track as near to the door as possible, in order to curtail the handling of engines without fire, to the minimum.

Sixth: Incoming tracks and outgoing tracks should be as distinctly separate as possible, otherwise delays will be common to ongoing engines unless the tracks shown at EE and FF are double, in which event more switch throwing would be necessary, which is an operation that should be eliminated as far as practicable.

With the exception of the above features, the general idea shown in Plan No. 2 is good, and would certainly provide a means of handling power very promptly.

The matter of facilities, as above described, is not all that goes to make for promptness and despatch in handling of power, however.

Grate rigging that is out of order, grates that do not open enough, and inadequate means for thawing out frozen-up ash pans, etc., being, we consider, very important factors.

Drainage along the incoming track should also be specially provided for in order to escape trouble in cold weather from ice building up from the drips common to the use of heaters and the working of injectors.

Regarding subject "B," heating and ventilating of roundhouses, your committee can offer no suggestion for an improvement over the plant of the

Lake Shore & Michigan Southern Railway, at Elkhart; this, in our opinion, being perfection itself along that line.

D. R. MACBAIN, Chairman,
C. E. CHAMBERS,
P. MAHER,
W. R. MCKEEN, JR.,
Committee.

JACKSON, MICH., May 6, 1905.

NOTE.—Mr. G. W. Wildin advises that he has not assisted in preparation of report and does not consider it fair to have name appear as one of committee.

(Vice-President Ball in the chair.)

THE VICE-PRESIDENT: Gentlemen, this subject is now open for discussion. I believe the Canadian Pacific Ry. has done a great deal in the way of improving terminal facilities, and we would like to hear from Mr. Vaughn, if he is in the room, on this subject.

MR. H. H. VAUGHAN (Can. Pac. Ry.): Our terminal facilities are peculiar in one way, and that is that at practically every point we only handle a small number of engines per day. We are not up against the big roundhouse proposition at all, except at Winnipeg, so that I would prefer to say nothing about track arrangements.

As far as heating and ventilating is concerned, I have had considerable experience both on the Lake Shore and the Canadian Pacific with the type of heating arrangement put in at Elkhart, the direct steam-heating system. A few years ago on the Lake Shore we equipped a total of sixteen roundhouses with that arrangement, and this year on the Canadian Pacific Road we have heated eight roundhouses by this system, and in all cases the results have been most satisfactory. We have not only been able to warm the houses, but we have done it at a saving in the coal consumed for heating over that which was used in previous years; the saving in coal alone being sufficient to justify the cost of putting in the heating plant, which I consider a very satisfactory result. The Elkhart roundhouse — and I trust Mr. Ball will excuse me for speaking about it — was constructed with a definite end in view. That was that the cold air, entering under

the doors, would be warmed by the pipes in the pit, and as the air ascended to the roof of the house it would carry with it the steam and smoke so common in roundhouses. That idea, I think, has been amply carried out in practice, and I feel very strongly that that form of house is the best section of house that has so far been devised if we want to keep the house clear of smoke and steam. At the last convention, when we had a topical discussion on this subject, I mentioned that we were going to enclose the turntable in the house. While that plan has been moderately successful, it has not been entirely so. The house we enclosed was heated with hot air in place of direct radiation, and the troubles that are so frequently met with in hot-air heating were very much accentuated in the closed house; that is, the drawing back of the smoke through the heating fan and its being thoroughly mixed with the air and driven out again, so that the whole house is filled, not with smoke that is opaque, but with smoke which affects the eyes and lungs of the men. I feel that if the house had been heated with direct radiation, so that in place of having a horizontal circulation of air we should have obtained a vertical circulation of air, that we should have had a successful house. The horizontal circulation of air which you get in a house heated with hot air is extremely troublesome unless the ventilation is first class. There is a tendency to draw the smoke into the fan. The hot-air people tell us we can correct that by taking in more outside air, which is perfectly correct, but if we take in more outside air, we run up the expense of heating the air very rapidly. All the cold air coming in has to be warmed up to the temperature of the house, in place of having to be kept warm, and in a cold climate it is impracticable on account of the expense. After an experience which we have had in the last two years, I agree that the system of heating and ventilation of roundhouses suggested in the report is probably the best, and I believe that system will avoid nearly all of the smoke and steam troubles provided one thing is attended to, and that is the proper height of jack and ventilator. We found that a short jack and short ventilator will not relieve the smoke trouble. We are now putting in ventilators 20 or 25 feet high, in order to get a good vertical draft through them.

MR. WM. MCINTOSH (C. R. R. N. J.): I would say a word in regard to the difficulty of heating a roundhouse with hot air from a horizontal direction. We found it practically impossible to obtain any satisfactory results from that method. The house I refer to, in addition to having the usual hot-air pipes along the largest circumference, elevated at a distance of about eight feet above the floor, with a right-angle elbow, had also chambers surrounding the pits through which hot air was forced, and which could be directed into the pit through portholes provided for that purpose. Our foreman suggested that as he was obtaining no service from the outer line of pipes, that I should permit him to close up some of them and see what he could do by taking air entirely through the ports in the pits. This was tried and proved so successful that we plugged up the outer line and directed the current through the pit openings entirely. After we did that we secured satisfactory results. I think in most cases it is practically impossible to obtain satisfactory roundhouse heating through air pipes carried at considerable distance above the floor. The air in that case does not come down to where you want it. It is gathered up by the general currents and carried out, but where you direct it into the house under the locomotives it will serve the purpose of thawing out the engines and will then circulate around through the house to much better advantage.

MR. F. F. GAINES (P. & R. Ry.): In connection with this paper, not so much the heating and ventilating end of it, as the facilities at terminals, I think one thing is very much overlooked — that is the cramping of the motive power in insufficient room and on insufficient tracks, and without any rational connection of the tracks between the different operations. Of course, in some of our newer and more modern plants this has been taken care of properly, but many of the older existing plants that are at times very busy and when we need the power badly, they are very congested, could be very greatly improved by taking this question up with the motive power officers and study out a rational, practicable system which would give you a better handling of the engines in continuous movement, instead of having to move forward and backward oftentimes over the same piece of track, to go to the ash track, the coal dump, and to go into the house again.

MR. W. E. SYMONS (K. C. So. Ry.): In connection with the recommendations, which I think are excellent and would be good general practice for us to follow, it occurs to me that in suggestion No. 5, "Turntable not less than 85 feet with (preferably) an electric motor as power for handling same," that we might be subjected to some little criticism in specifying or preferring an electric motor, in that a number of roads are very successfully, and as I understand, satisfactorily, using power motors driven by air or gasoline. While I think a power motor is the proper means of turning the table, it occurred to me that we should not specify an electric motor.

In recommendation 4 I notice the method of loading cinders into an ordinary steel car equipment by means of a conveyor recommended, while in the third paragraph of the objections it is stated that "modern steel cars are not, in our opinion, suitable for cinder work, inasmuch as the bottom dumps provide a very poor means of distributing cinders along the right of way for ballast, for which purpose, in most cases, they are used." This does not seem to me to harmonize and it occurred to me we were possibly inviting criticism as to our ability to design steel cars suitable for the work, in excluding the use of steel cars for handling cinders.

MR. D. R. MACBAIN (Mich. Cent. R. R.): The committee had reference to the steel cars provided for the transportation of coal. That is what Mr. McKeen had in mind when he made that recommendation — these were the cars he had in mind to utilize for the transportation and distribution of cinders, but in considering the thing the committee saw that it was impracticable to use these cars for that purpose, inasmuch as cinders could not well be distributed along the sides of the track where they are needed.

MR. GEORGE W. WEST (N. Y. O. & W. Ry.): We have several turntables which are operated by compressed air and they work very successfully summer and winter.

In regard to the heating and ventilating of roundhouses, our company built a new roundhouse last fall, and during the past winter, which was a very severe one, it was heated by the Sturtevant system of hot air. I must say that the roundhouse is a most comfortable place to work in, and was freer from smoke than

any roundhouse I have ever been in. We had no trouble in removing the ice from the under side of the engine in one hour. The ice would begin to drip from around the engine truck spokes in fifteen minutes after the engine came in. The air was all taken in, in the manner mentioned in the paper. We got all the air through portholes in the pits, and as I have said, the roundhouse was very warm and very comfortable to work in, and the ventilation was perfect.

MR. J. F. DEEMS (N. Y. C. & H. R. R. R.): I want to say a word in the way of explanation. The explanation may be in the paper somewhere, but I do not know that it is. The last clause on page 10 refers to the heating and ventilating of the roundhouse at Elkhart, Ind., and the committee expressed its opinion of that system as being perfection itself along that line. I want to say that the roundhouse is not heated with the hot-blast system. It is heated with what I consider a rational and perfect system; it is heated by an arrangement of radiating pipes in the pits and around the outer circumference of the roundhouse. I offer this in explanation, as it occurred to me some one might think it was heated with hot air.

MR. J. F. WALSH (C. & O. Ry.): Referring to what Mr. Symons said a moment ago concerning the advisability of the use of the electric motor on turntables, I will say that we have on all our turntables and transfer tables a simple air motor which gives us excellent results, and at division terminals, where the engines turn, but where we have no roundhouse or terminal men, or ashpits, but we do have turntables, we find it handy to have the same motor installed and make use of the motor by coupling the air pipe to the air hose on the engine.

While we are on the subject of terminal facilities I would say to you that our experience with the self-propelling 3,000-pound crane at places where you do not have room or the means for installing a modern coal plant, we have reduced the cost of our coal, and our loading expenses, from thirteen men to six men, by the installation of a self-propelling crane. It will clean out a gondola car, with the exception of the corners, and fifteen minutes' work on the part of a man with a shovel will get the coal out of the corners. It will also take the ashes out of a level track

or pit, and it is quite handy in every way. I mention these things with the hope that some of our members may profit by the suggestion.

(President Peck in the chair.)

MR. JOHN J. ELLIS (C. St. P. M. & O. Ry.): We handle our ashes by a depressed track in connection with a pneumatic cinder hoist. Our cinder pit has three buckets on portable trucks, which run on an inclined track; when the buckets are filled with ashes they are run down the inclined track and hooked on to the pneumatic cylinder and raised up; then by means of vertical cylinder the horizontal cylinder with bucket is run to car and dumped. The fulcrum on bucket is so arranged that bucket tips very easily. I think it is about the best system I have seen in my travels, and less expensive, as the dispatcher's helper who cleans the ashpans does all the work in emptying the buckets on the cars. Under our old system the cinders had to be shoveled from the pit to the ground and then to car. I have eight terminals on our road equipped with the same device, and they are a perfect success from an economical standpoint, saving lots of money in labor every month, and the system works perfectly.

With reference to the heating: We use exhaust steam with steam pipes in the pits.

MR. T. N. CURTIS (L. & N. R. R.): In Fig. 3 I notice that the cinder pit and depressed track are opposite the coal chute. I think that is an error which is met with in a large number of terminals. It has been my experience that if the tender is filled with coal under these circumstances it rolls off, and half of the coal that rolls off rolls into the cinder pit or into the ash car. In my opinion it is a good thing to separate the cinder pit and the coaling devices entirely, so that the coal which falls off the tender does not fall directly into the cinder car.

MR. D. R. MACBAIN: I will say that the conditions are such at the point illustrated in print No. 3 as not to permit of having the coal chutes far enough removed from the clinker pits to locate them as Mr. Curtis suggests. There is not space enough. The excellent chutes provided for the coaling of locomotives at that place make it possible to put on a very big load with very little

of the coal spilling over the sides. We do not gather up a carload of coal in two months.

W. D. Robb (Grand Trunk Ry.): We have built within the past four or five years seven or eight new roundhouse terminals, and I think we have in some respects departed from the practice which appears to be in vogue on other roads. In the arrangement of the roundhouse terminals the coal chute is put far enough away from the ashpit so that the engines will not be blocked; in other words, an engine should always be able to get coal, there being sufficient room between the coal chute and ashpits for incoming engines. One reason for doing this is that on the road I am connected with the engineers take their own coal, and the coal chutes are the long trestle trough type of chutes without partition. The coal is dumped into the troughs from hopper-bottom cars and the fireman delivers to the engine what coal it requires. At the end of the coal chute we have the sand delivery device, operated by air. At points where we are limited as to room and the long chute can not be erected, the bucket elevator chute is built, the same distance being maintained from the ashpit if possible to do so.

There are two ashpits with tracks leading from the coal chute. The ashpits are 50 feet long, equipped with the overhead hoist, buckets, etc., the ashes being raked into the buckets and hoisted by air into the cinder cars, the cinder car track being between the two ashpits. This system of handling cinders on the Grank Trunk has been in vogue for about fifteen years. In the country in which we operate, the winters being so cold, it is necessary to have the ashpits as close to the shop as possible, so that the engines will have only a short distance to go after getting their fires cleaned before being housed. We therefore place these pits about 175 feet from the turntable. The turntables are outside, and for the past four or five years have been operated by air, which is entirely successful. On account of the cold weather and the amount of snow in winter time we have a set of pipes running around the turntable rail and in the center of the pit, which are heated by the regular heating system from the shop. This keeps the table free from trouble and enables it to work equally as well in cold as in warm weather.

Our shop system of heating is entirely different from anything I have heard of here today, as we heat the shop by hot-water radiation, the heat being obtained from the exhaust of the stationary engine, air compressor, pumps, etc., no live steam whatever being used for heating purposes. A reservoir is used for washing out into which exhaust steam is turned, also into the same tank is blown the water and steam from all engines that are required to be washed out. A partition is in this tank into which the exhaust steam is received from the pumps, air compressors, etc. A pump is connected to this system which draws hot water, putting it through the superheater and around the shop, which is sufficient to maintain a temperature of 70° even in the coldest weather. We have no ventilators and do not require them, as although the weather is sometimes very cold (at times as low as 20 or 25 below zero) the system of taking care of the steam when blowing off the engines does not allow any of it to escape into the shop.

THE PRESIDENT: My experience is that we have terminals all around, nothing but terminals, and we have no room. If we had room enough we could handle the terminal question, but as a rule we have twenty engines on a 10-engine track.

MR. JOHN J. ELLIS: Our method of handling engines is for them to take coal, clean the ashpans, take sand and take water, so that the engine when it goes into the yard, is all ready for service.

MR. WM. MCINTOSH (C. R. R. of N. J.): I would mention that in the discussion of turntable motors, I do not recall anything having been said about gasoline motors. There are a number of these used for driving turntables and they are successful. We have had some experience with that type as well as the electric, and the gasoline machine should not be lost sight of in this connection.

With reference to steel cars for handling cinders, we contributed to a design of cars for that purpose that were built by the Standard Steel Company about a year ago, and have been in operation at our works since, and given us excellent service. A number of these cars have been built for other lines too, and I understand they are quite popular.

MR. E. W. PRATT (C. & N. W. Ry.): I notice on page 4 it refers to the protection of the concrete columns with No. 10 iron. I believe that nothing but cast iron should be used in the cinder pit on account of the liability of dispatching a large number of engines one after the other and the pit becoming full of hot cinders. I have little doubt if any of us who, having had charge of roundhouses or terminal facilities where there is a depressed track, have been at such place very long without having the bumper post or end wall or embankment, or whatever is supposed to stop the cars, knocked down or the cars wrecked. If you look at print No. 2, you will find that it does not show whether it is a stone wall or a bumper post, against which the cars in the depressed track go. We have had a similar arrangement, and I would say that in a couple of instances we have knocked the walls down and kept the masons busy a good deal of the time. We have done away with the stub end track entirely, and run it up on a 20 per cent grade, and bring it into one of the other tracks if there is sufficient room. At small roundhouses that makes a very convenient method for loading old wheels and unloading new ones.

I will ask Mr. Vaughan if he recollects the proportion of square feet of heating surface per cubic foot for direct radiation in the roundhouse he refers to.

MR. VAUGHAN: I could not give you the square feet of heating surface, but there are four rows of pipes in each pit; four rows of 2-inch pipes the full length of the pit.

MR. PRATT: Any wall radiation?

MR. VAUGHAN: If we can not get sufficient radiation in the pits we use wall radiation, the equivalent of two rows of pipes around the entire house.

MR. T. E. ADAMS (St. Louis Southwestern Ry.): I would ask if any of the members have had any experience with cast-steel rail stands in place of cast iron? We have had a good deal of trouble with cast-iron rail stands, and the cast-steel stands have been introduced.

MR. F. M. WHYTE: I understand that Mr. McKeen's layout is an ideal one, and that it has not been constructed. Am I right in that?

MR. MACBAIN: Mr. McKeen's layout is ideal.

MR. F. M. WHYTE: We might criticize Mr. McKeen's suggestion even at greater length. I wish to add my approval to the suggestions that Mr. MacBain makes, to and including the sixth, but I do not agree with his concluding sentence, " with the exception of the above features, the general idea shown in plan No. 2 is good, and would certainly provide a means of handling power very promptly." I think that the handling of power at such a plant would be very slow. The size of the house would indicate that there ought to be handled at least more than one hundred engines in twenty-four hours. He shows one small ashpit opposite the coal trestle and judging from the size of it — of course the dimensions are not given — only one locomotive could be placed on the ashpit at a time. I doubt whether one hundred locomotives could be passed over that one ashpit in twenty-four hours. The neck is right there at the ashpit. The coal supply is shown there also, and the coal must be taken into the mechanical plant from the locomotive running track. There would be serious delays in getting the coal in and getting the ashes out. Apparently there is no ashpit on the outgoing track.

The report seems to make no mention of drop-pits or of mechanical hoists over the drop-pits, and these would seem to be important in an engine-house of any size. Reference is made to swinging doors, and I presume the committee prefers swinging doors, although there have been made some rolling doors which have given considerable satisfaction.

The system of ventilators on top of the engine-house for the passage of steam and the waste products of the locomotive is apt to be a delusion. If it is a Monitor roof it probably will not amount to much. It should be a ventilator up which some hot air is passed in order to create a draft. Mr. McKeen says that the low flat roof engine-house is to be discouraged; so is the high roof engine-house to be discouraged, because the larger the volume of the house the more heat will be required and the more coal will be required to heat it. The roof, of course, may be too near the ground, but at a reasonable distance it should be possible to ventilate the house without the use of a monitor. The scheme which is shown for the Michigan Central is, I think, so far as the

outside layout is concerned, an ideal one. The criticism on that is that the locomotives from the going in track are switched back on to the engine-house track, and probably this could not have been corrected in the space available and the adaptation of the old layout.

So far as concerns mechanical devices for handling ashes, I may say that after considerable investigation we have found that they do not meet with favor; that a large majority of the roads prefer the pit underneath the locomotive track from which the ashes are shovelled into a car on a depressed track.

THE PRESIDENT: Is there any further discussion of this subject? If not we will pass to the next business, which is the discussion of the individual paper by Mr. George M. Basford on "The Technical Education of Railroad Employes: The Men of the Future."

THE SECRETARY: Before we begin the discussion of the paper by Mr. Basford I would say that if you will look at your programs you will find that we have a topical discussion under the head of "Stay Bolts," and further on there is to be a discussion of the report of the Committee on Flexible Stay Bolts. The member to whom was assigned the subject of stay bolts, sent word that he would not be able to open the topical discussion of that subject. I was not able to assign the topic to any other member.

The report of the Committee on Flexible Stay Bolts is simply a report of progress. They have no recommendation to make and ask to be continued. In order that a very free discussion of Mr. Basford's paper may be had, I would suggest that we take up the discussion of that paper and assign the entire noon hour to that subject, or so much of that time as may be required.

THE PRESIDENT: We will now consider Mr. Basford's paper.

Mr. Basford read the paper as follows:

THE TECHNICAL EDUCATION OF RAILROAD EMPLOYES—THE MEN OF THE FUTURE.

THE PROBLEM.

No other part of industrial development has shown such progress as that of transportation, and no other influence in human welfare is as vital as that exerted by the railroads. In connection with this progress and

development, because of its radical character and great extent, the development of men has been allowed to take care of itself until it must be said that the most vital railroad problem of to-day is that of men.

The engineering and the operating situation on railroads is in advance of its men, and in many ways the problem has outgrown both the individual and methods of dealing with the individual, and especially has it outstripped methods of preparing men for their work. These suggestions are prompted by a desire to present a possible, simple and consistent solution of the problem of the men of the future. A pyramid is typical of what is needed. The pyramids have outlived centuries, but they could not if they were not planted on their bases. Our railroad pyramid is resting on its apex.

The plan begins with careful selection of recruits. This is followed by a scheme of education, carried out by the railroads themselves, beginning at the recruiting and consistently followed with a view of raising each individual to the limit of his capacity.

It is based upon the rank and file, the results looked for being a broad base of well-equipped men who will apply knowledge and thought to their work with an appreciation of their responsibilities and obligations to their employers, their associates, the public and themselves. From among these it should be easy to discover those who are capable of subordinate official responsibility, to meet the present need of leadership talent in many strenuous positions upon which the efficiency of operation largely depends.

The only real difficulty is to educate the higher officials and the owners of railroads, to realize the need and to provide definitely, adequately and permanently for it. Few among the owners of railroads are doing anything to assure a stable, definite, systematic and self-sustaining policy of conducting operation, and few appear to appreciate the necessity for providing for the future. What is worse, few even appreciate that there will be a future, the present is so absorbing.

The greatest need lies in the motive power department, but the plan must not end there. It must provide for recruiting and for the preparation and education of the recruits of other departments.

THE MOTIVE POWER OFFICIAL.

With the general railroad progress of the present generation the motive power problem is an example of one which has grown to an extent appreciated only by those who have watched it intently.

As a superintendent of motive power a generation ago, a good mechanic sufficed. He was an old locomotive runner, or a shop foreman promoted, and he was usually called "master mechanic." It was but a short and comparatively easy step from the locomotive, or the shop, to the position of head of the department. In the present day of record-making, of heavy

locomotives, large-capacity cars, strenuous operation, large shops and intricate labor problems, such a step is now a hopelessly long one.

The sort of man who successfully directed the department twenty-five years ago would find his ability overtaxed to properly manage a single busy roundhouse to-day. A different kind of ability is now required to direct the mechanical department of a single progressive road, and as great roads combine into systems still another new kind of a man will be needed. He must soon be ready, for his work is even now waiting. Is this appreciated? Are the men being prepared?

Other departments have their problems, but where are the officials required to have as many different difficult qualifications as in the motive power department? Who must be as many kinds of a successful man as a superintendent of motive power? Where else must a man be an engineer, a business man, an organizer, an executive, a manufacturer and a diplomat? Where else are men required to know as much as these officials must know? What other railroad official is there who must compete against conditions of labor and management with the best industrial establishments? Who else on the road has anything like the locomotive, or like shop piece work to deal with? But these are merely items among the cares of these officials. Is any one doing anything systematically and seriously to permanently improve the labor situation? This is but another part of the problem these officials are given to solve.

It is no small task to properly direct the design, to operate and maintain a thousand or more traveling power stations, such as modern locomotives have become, and to build up a policy and an organization sufficient for such an undertaking on a single road, let alone doing this for a combination of roads. No other class of men in the world — without exception — is ever called upon to do what is everywhere expected of motive power officials, and the demands increase continually. The problem has grown perceptibly in two years and enormously in five.

The problem is that of men, the selection, preparation and training of men. If this is provided for the rest is easy. It is said to be less difficult to secure a new president than to secure a good shop or roundhouse foreman. This is, of course, not true, but it certainly is sufficiently difficult to obtain the necessary supply of foremen of the right sort and even more difficult to secure the right kind of men in the ranks. The men are not essentially different from those of a generation ago, but the conditions certainly are different. To improve conditions it is necessary to know what is wrong, and to know what is wrong it is necessary to understand the changes which the last few years have brought.

WHAT GROWTH HAS DONE.

A few years ago railroad mileage was in hundreds, whereas now it is in tens of thousands. The general manager once knew all of his subordinate officials, because they were few and changes were not fre-

quent. He once knew all of his master mechanics, station agents, conductors, engineers, dispatchers and even telegraph operators. They knew him and were working for him because he was personally close to them in their work. All this has changed as the roads themselves became greater and as roads great in themselves combined into systems, as has never been done anywhere else in the world. With this change the officials have by a powerful current been carried far from the men in the ranks and far even from their subordinate officials. From personal friends, the men have become to them as mere numbers.

For example, we have one motive power official who is responsible for the service of more than forty thousand men. How many of them can he know? He does well to really know his chiefs of staff. From a simple business proposition, administration of railroads has become like the direction of the armies of a nation. But armies do not suffer weakness of organization because of increasing in size. An army becomes larger by aggregation of units, which of themselves become no larger. As size increases general officers are added. The commanding officer does not know all his men, but the captains do know theirs. From this standpoint the railroads need more captains, because the subordinate officials now know their men as little as the chiefs know their subordinate officers.

The recruiting and training is the same for a large as for a small army, because the units are of the same size. It is not so with railroads. For example, consider the organization of a new and large locomotive shop compared with a small one. This is one reason why the large shops of to-day are less efficient and less economical than the small ones. Shops have outgrown both men and methods.

THE RECRUITING OF THE PAST.

Considering shop forces, the recruiting of the past was through apprenticeship. It is not so to-day. One of the best equipped railroad boiler shops in the country has not a single apprentice and few of them have enough to be worth mentioning. Of twelve trades in one shop plant only three were found to have apprentices, but all had shop committees. In other departments apprenticeship has been overlooked and neglected because there was so much else to do. There has been too much pressure to turn out work with existing facilities to admit of taking the necessary precautions concerning the men and the leaders of the future. The present demand for foremen with leadership talent and executive possibilities proves both the neglect of the apprentice and the distance which has grown between the officials and the men, for there certainly must be latent talent, dormant and undiscovered, sufficient for all necessities.

We need to be reminded that many men in the ranks are sure to rise in one way or another. If they are not encouraged in every possible way to qualify for higher positions on the staff they will employ their leader-

ship in other directions, and here is an opportunity to reach one of the roots of the labor problem which has already been allowed to wait too long.

The writer recently discussed this subject with a railroad official, who, with a gesture toward his shop, said: "I have here twenty-five hundred men and not one of them can I promote to take charge of a roundhouse which is badly in need of a foreman." It can not be true that of that number not one was worthy and prepared for advancement, but that official believed it to be so, which is nearly as bad. Another well-known superintendent of motive power says: "I have more trouble in getting proper pay for foremen than to find good men to act in that capacity. If a job is worth $150 per month I find difficulty in getting a $150-man to take it at $90 per month." This is another vital matter. Because railroads are neglecting organization methods, it is the exception rather than the rule, to promote mechanical officials to fill vacancies. It is not safe to continue this. The officials must be encouraged by promotion and they must be required to know their subordinates in order to promote them. Under the old apprentice system ability was quickly discovered, and in proof of this the best high officials of the time have come through apprenticeship, and most of them rose rapidly.

To-day telegraph operators, firemen, trainmen and others are usually taken from outside the service. They receive less preparation for their work than when there was less responsibility and less to do. The recruiting system is at fault, this being considered as unimportant. It is not so in England and in Europe, where the efficiency of the individual railroad employee is of the highest type.

Apprenticeship of the old kind was an ideal method of recruiting. Boys were carefully selected, conscientiously trained, and the employer exercised a moral as well as an educational influence over them. The present pace does not permit of such a system, yet the lack of it has brought a deplorable condition, and to take its place something is needed and that quickly.

A SERIOUS MISTAKE.

For twenty years the railroads have sought to provide the necessary leadership from the technical colleges and many strong officials have developed through what is known as the special apprentice system. It is perhaps possible to meet the immediate need in some such way; but when the technical school graduates come to the railroads, as outsiders, from the schools — as they usually do — this system is doing a fundamental injury, which is neither understood nor appreciated, but it is nevertheless serious. Every time a special apprentice is started on his course notice is, in effect, served upon the men and boys with whom he works, that he, because of his education, is to acquire in a few years sufficient knowledge, experience and ability to become one of the official staff. The effect in the shop is to discourage those who have not had such education.

The special training of young men from without the ranks of the workers, for official positions, is fundamentally wrong, and, furthermore, it plays strongly into the hands of those who wish to see men leveled into classes, and considered as on uniform levels, as to the value of service. It may be necessary to continue special apprenticeship for a time. Technically educated men are needed and will be needed even more in the future, but they should come from the ranks and not from outside of the service. The present system, or any other system, which in any way serves to discourage the regular apprentices and thereby tends to cut off the source from which most of the successful men have come should give place to a system which will encourage all by making it possible for the lowest to become the highest in the briefest possible time, because the talent is needed now. Nothing adequately meeting the needs of American railroads has been accomplished either here or abroad. That such a system is possible and feasible can now be shown.

THE PLAN.

The suggestion is that recruits in shops (and this applies in principle, though not in detail, to other service) should be taken in as apprentices. They should be given shop training, which will increase their earning capacity to the utmost, and they should be placed under the direction of men of such character and moral influence as to lead them to form correct, broad and honest views of life and their proper relations with other men and their employers. Parallel with the shop training, attendance during working hours at a school provided and maintained by the road should be required; and for this a new kind of a school must be developed, as a new kind of apprenticeship must be developed — the kind that will meet the individual cases. They must not be dealt with in classes or by fixed rules. The school must be one wherein the shop and the studies go hand in hand. While the shop hours are taken for the school, home work should be rigidly required. Life must not be made too easy for the apprentices.

For example: Arithmetic is needed of the kind which will deal with pulleys, back gears, lead screws and other studies such as drafting and shop arithmetic, which will reveal the reasons for things seen and done in the shops. The school and the shop should be coördinate in every possible way. The local officials must be interested in and responsible for the boys in the school as well as in the shop. The higher department officials must be occasionally seen in the schoolroom and the foremen should be identified with it. An evening a month should be devoted to a general meeting of an apprentice organization, with an occasional stereopticon talk or lecture by a foreman or higher official. Here is an opportunity for the university extension idea. The boys should visit other shops in committees and report their observations for discussions. A library for books and periodicals is a necessary element. If the road has several shops a car should be equipped with valve motion models, sectioned

locomotive apparatus and appliances, electric motors and generators and even a small stationary engine for the boys to study, dismantle, assemble and set the valves. The air-brake cars have shown us how to use school cars.

As a part of the plan, every roundhouse should have a comfortable reading-room, provided by the company, with books, periodicals, charts and models. Every encouragement should be given the engineers and firemen to organize improvement clubs. The company should furnish stereopticons and occasional lecturers. Progressive education should accompany the present tendency toward progressive examinations. Here is another opportunity for university extension. Engineers and firemen should be educated to do their best, and it is important to bear in mind the fact that the difference between the work of the best and of the average man represents more to the road than the economies to be obtained from the best fuel-saving appliance or invention ever brought out.

An important opportunity for exerting a strong moral influence is available in this plan and an insight into the history of nations, political economy, the history of labor and the proper relations between employer and employee can be given. The scheme is not Utopian but practical, and the way is plain. The idea has been put by Milton P. Higgins in these words: "The object is to produce many well-trained and educated workmen, some foremen, and from the foremen a few superintendents." This structure represents a pyramid resting upon its base. As long as we seek the genius we stand the pyramid upon its apex and put it into a state of nervous equilibrium. "We may hope for much from a thousand educated, thinking expert American machinists, who have the skill, education and exact knowledge of the shops. Is not the production of one hundred well-educated workmen a more certain undertaking than the production of one genius?"

We are to-day looking for the genius and overlooking the good workmen, but by providing for many workmen we can not fail to find the necessary genius.

This school shop enterprise should be carried out for the individual, lifting each as high as he can go. It should leave the capable student prepared for a course in a technical school. An important part of the plan is a provision for sending, every year, a certain number of graduated apprentices to a technical school, for a short "sandwich" course, at the expense of the company. This should be held out as a prize or reward for high standing in the shop and school. This would provide technical men and they would be admirably prepared. Even if only one out of ten remains in the service the encouragement due to the possibility of securing such an education would affect every ambitious apprentice and every ambitious workman on the road.

It may be said that enough apprentices can not be found. Perhaps not the first day, but when the plan becomes known there can be no diffi-

culty. In time, perhaps, the labor unions will cease to discourage and restrict apprenticeship. At present it must be confessed that little is accomplished by the apprentices we have. If the apprentice and the apprentice's father see the possibility of education in the shop, leading to the possibility of a college training at the end, the whole shop attitude should change on this and many other matters. Some of the boys will leave the service, and well they may, for there will be many others; but places should be available, under present conditions, on every railroad for all who finish such a course.

The character and methods of the school have been considered and they may be discussed when some railroad is ready to seriously consider the subject.

Shop apprentices are prominent in the preceding paragraphs, but the need of and the demand for education lies not alone with them. Such a school would from the first be overwhelmed with applications for evening instruction of shop men and others, including foremen. Engineers and firemen will need to be provided for and the educational plan would necessarily develop into an important factor, for, in spite of themselves, railroads are sure to find it necessary to undertake the education of their men. This can not be left to outside influence of any kind. In the hands of the officials themselves it will become a powerful instrument in dealing with the problems of the future, and especially the labor problem.

With such a system the shop could probably in time supply all firemen, engineers and men for other service, in which the education, training and the *esprit de corps,* which would naturally be developed, would be most valuable. There is no reason why the traveling engineers should not coöperate with the teachers of the apprentice schools in the development of correspondence courses for engineers and firemen and the men would unquestionably respond, certainly as well as they do at present to the commercial correspondence schools. Having the shop schools, they may be taken to the student in every department by the correspondence method, whether he is on an engine, at a telegraph key, on the track or in an office. The development may be as broad as the need, and correspondence courses may be made a vital factor in the plan, and university extension an important element. Those who can not attend the schools must be provided for.

Some will say, "But where are the men who can conduct such schools?" They must be the best teachers to be had and they must thoroughly understand the apprentice. These men are now doing somewhat similar work in many of our large cities and they are to be found when wanted. Some one else may say that all this has been done by the Baltimore & Ohio and proved a failure. There were reasons for that failure. The plan here outlined is believed to contain vitally important elements which have never failed, perhaps because they have never been tried. Some one will speak of the expense. The cost is insignificant. The work must not be started except upon an appropriation sufficient for ten

years, which can not be thoughtlessly withdrawn even by the directors themselves. That length of time will be required in order to give the idea a proper trial and in that time the benefits will obscure the cost.

It seems possible that the future of the motive power officer and of his department, and of other officers as well, may become clearer and the outlook may be brighter when the needs are provided for in such a way. The word education, as distinguished from instruction, seems to represent what is needed, and it is clear that the education of managements and owners of railroads is the first step to be undertaken. If this is done there will be no problem too difficult to be solved, but if not there are many impossible of solution. Only in some such way as this can the officials get close to the men directly or indirectly.

No railroad with a constantly changing policy, or one on which the tenure of official life is uncertain, should for a moment seriously consider such a suggestion as is here outlined.

Shall this (or something better) be done? The writer believes that the future, not only of the motive power officer, but of the railroads, and to a large extent of the country, depends on the answer.

There is no need of worrying about the college man, he is fully capable of taking care of himself, and it will be really a favor to him to put him entirely upon his own resources. He should not be handicapped by being labeled, because of his education. Special provision in the shops for the graduate of a technical college should not be made. Employers should not modify their methods for him. To do so is not advantageous to the college man, or to the other men in the shops.

The condition and position of the superintendent of motive power should be elevated and improved, so that young men will see that they can afford to spend their lives preparing for the highest positions. They will then be impressed with the fact that to secure such a position is worth a lifetime of conscientious and unwavering effort. This is not the case to-day.

WHAT HAS BEEN DONE ELSEWHERE?

A study of the educational system of the British Admiralty compels admiration for the plan which, for sixty years, has furnished the men who have built the shipping of England. The method begins with apprenticeship, combined with schools and the naval college. By a process of selection, through healthy competition, ability is easily discovered, and those who are fitted are raised to the very highest positions. All pass through the sieve of selection, and those who wish to remain in it, after its first shake, must strive for the opportunity. The boys attend school at the works several afternoons each week, continuing their studies independently in the evenings. They also receive shop instruction as apprentices. Continuance of the school work in the second year is determined by examinations. Through later examinations selections are made for a certain

number to attend Keyham College and afterward the Royal Naval College at Greenwich.

Mr. Dugald Drummond, locomotive engineer of the London & South-Western Railway, has established a system whereby the apprentices of the Nine Elms Works attend day classes at the neighboring Battersea Polytechnic Institute, the courses of instruction for them being under his control and direction. It is understood that promotion upon the completion of apprenticeship will depend upon proficiency in the school as well as in the shop. This has been recently inaugurated and promises to be very successful.

The Great Eastern Railway has 737 apprentices at Stratford, and for fifty-three years has maintained a Mechanics' Institute near the works. The number of apprentices voluntarily attending evening classes last year was 303. In order to encourage further study among its employee-students, the company in January, 1904, established apprentice classes during working hours, with elementary educational requirements, those who qualify being allowed to attend without loss of pay. The plan of these day courses is admirable. To encourage higher technical education, leave of absence with full pay is granted to employee-students who comply with certain conditions and pass certain examinations.

The Lancashire & Yorkshire Railway controls at Horwich a Railway Mechanics' Institute. In spite of overtime during a busy winter 719 individual students attended classes, as indicated by the latest annual report.

The London & Northeastern Railway has conducted the Crewe Mechanics' Institute at Crewe for fifty-seven years. According to a recent annual report it provides evening instruction for eighteen hundred students. This road has 1,077 apprentices at Crewe. The students of this school have taken more Whitworth scholarships than the students of any other one institution in England. For thirty-two years this institute was directed by Mr. F. W. Webb, formerly chief mechanical engineer of the road, and it is stated that he never missed a meeting of its officers.

At Swindon the Great Western Railway has for fifty-nine years conducted its Mechanics' Institution. From this has developed a system of day classes for apprentices at the Swindon and North Wilts Technical School. Classes are held from 2:30 to 5:30 P.M. on Mondays and Saturdays, and students must meet certain educational requirements. The classes are under the supervision of the head of the motive power department. Evening classes are provided for all apprentices. The day classes are offered as a privilege to a limited number of students only, progress to further instruction being dependent upon examinations. These students receive full pay for their time at the school, for three years, and the school fees are paid by the company. Students who distinguish themselves are allowed to spend part of their last year in the drawing office and chemical laboratory.

CONCLUSION.

For the men and officials of the future, technical education is required, but it must be obtained while the student otherwise prepares himself for his work. It must go hand in hand with his education in the service, and the education must be arranged especially to suit his needs. For the engineering education he must not be required to fit himself to existing schools. A new school must be developed specially for him. Instead of giving years to subjects which are merely good for mental training he must give months to those which he will remember. Moreover he must not separate himself from active work and responsibility for long periods in order to attend school.

An adaptation of the Admiralty and Drummond plans would seem to fit American railroad conditions. These developed naturally, quietly and effectively. They are the work of broad-minded men. When the men who are making American railroads interest themselves in the problem an even greater plan will be forthcoming. They should not delay, for the need is imperative.

Are we a nation so enveloped in a cloak of progress that we can not see the future?

MR. G. M. BASFORD: The object of this paper is to state a need and utter a warning. It has been said that this is not the place in which to launch an effort of this kind and that the attention of the higher officials is the first requisite. It is true that those officials must be interested and that they must act, but they will not act until the necessity is plainly and definitely placed before them. There is reason to believe that many managing officials do not appreciate the need of education of recruits and the pressure should therefore be applied by those who do appreciate it.

This paper is inspired by a desire to impress this Association with the necessity for action which will compel attention to this too long neglected problem. The situation justifies the statement that mechanical department officials, for their own preservation, must attack it in such a way as to compel the owners of railroads to provide for it. It is not too much to say that if this problem is not properly met superintendents of motive power can not hold their jobs.

With a firm conviction that nothing difficult is suggested and that the movement once started will gather momentum and lead to

a perfect success, the plan of educating recruits to the service is respectfully placed before you. If you do not agree with this suggestion I hope you will propose something better.

F. F. GAINES (P. & R. R. R.): Mr. President, I think Mr. Basford has given us a very admirable paper on this subject, and there is no question but that the note of warning in it is justified and needs to be heeded. I have had occasion to look into the apprentice question quite a little in connection with outlining a course for apprentices for large shops, and there is only one flaw that I can find in the whole arrangement, and that is the necessity of catching your hare before you cook it. Now, the American boy of to-day — I do not know whether it is due to less discipline by the parents, more liberty on the part of the boy, or what, but the fact remains that the boy of sixteen to twenty-five, we will say — the boy and young man — are not attracted by their future career and they are not building very much on it. Among the class of young men that we desire to get as apprentices their parents do not take, or will not take, interest enough in the matter to guide them, and the young men will not of their own initiative take it up, and the question that we have to face is, "How are you going to get hold of these desirable young men?" I know from what I can see and from having looked into the thing that the average boy cares only about the little money he can make and where to go nights to spend it, and not about working or studying or anything else, and until we make some radical change, you might almost say, in our young men and boys, I do not see exactly how we are going to carry out this program, desirable as it may be.

MR. JOHN TONGUE (M. & St. L. Ry.): Mr. President, to prepare apprentice boys it is necessary to have good foremen. There are foremen of different kinds, and if the foremen do not interest themselves to educate the apprentices, you are going to have very poor workmen. There is no question but the foremen can take the place of the parent, in fact, to much better advantage than the parent can himself. It will be by the constant and daily touch of the foreman with his apprentices that he can bring them to such a state of interest that they will think of their future. It is no use to say that it is not possible to have boys think of their

future. If you take them in the right way you will lead them to think of what is best for their interests and their welfare. There are too many men around this country who have served their time in shops where a large number of apprentices have been employed that are holding to-day the best positions that there are in the United States, and it is owing to the fact that an interest has been taken in the apprentice boys to show them the light in which they should walk. We should not lose sight of the necessary interest due the apprentice boy by having proper foremen for his education. You may have a foreman — what I call a "stand-around foreman" — that tells a fellow to do this and do that, but does not explain to the apprentice boy the thorough practical way of doing the work; he is not the man to tell him to take up any class of work which he sees the workmen doing in the shop and figure it out in his mind how he would do the work. If you do not talk to the boy in this line and show him that he can do work in his mind as well as he could by the machine, you are not educating the boy. Give him the work to do, ask him how he would do it; come around again in half an hour or an hour or so during the day and let him give you his opinion. There are many lines in which you can work apprentices, and there is no time that is better spent than in having a foreman who is a real foreman consider how to handle the apprentice.

PROF. W. F. M. GOSS (Purdue University): Mr. President and gentlemen, no one will deny the need of apprentices in our modern shops. I know that there are difficulties in maintaining them, which are in part the outgrowth of objections of the journeyman. It seems to me that any such objection is founded upon a mistaken view of the situation, and must be overcome. Certain it is that no workman can have valid objection to a system which is to train his own son, and it seems to me that when the workmen of any shop come to understand that a well-developed system of apprenticeship is devised for the purpose of training his own children and his neighbor's children, that one phase of the present problem will be made easy.

Then, of course, it is equally true that the apprenticeship must be made attractive to the young men, else, as has been said, the young men do not come. A young man must see a future in the

forge shop or boiler shop or he will not enter. It was easy to secure apprentices when shops were small and those in charge were interested in the young men of the neighborhood, for then the personality of the foreman or Master Mechanic constituted a medium of communication between men and company, both inside and outside of the shop. It is difficult to-day when shops have become large and there is lacking within their organization that personal interest in young men which is essential to the success of the apprentice. Many of the manufacturing establishments are meeting this condition by a separate organization which shall have charge of the apprentices in their shops, and it is clear to my mind that railroad companies will need to do something of the same sort. The purpose of such an organization is to provide some person or some group of persons, especially charged with the duty of securing young men to become apprentices, of detailing them to the different departments when secured, and of seeing to it that their work is changed with sufficient frequency to insure their thorough training. To such an organization, the standing of every apprentice is known. Earnest boys are encouraged while triflers are soon weeded out. By such a system, the management of a modern large shop supplies an element of personal interest in the apprentice, which is necessary to the successful operation of any undertaking involving the coöperation of young men. The writer of the paper would go one step further, and advocates the introducing of some actual school work into the program of the apprentice. I believe that the adoption of such a plan would be wise but I do not regard it as a fundamental proposition, nor as the first thing to be done. It is rather one of those things which may be allowed to come as the heaping of the measure which has been first filled by the establishment of a system which will interest an official in the apprentice, and convince him that this interest is genuine.

I would add an expression of my very great interest in the paper which Mr. Basford has presented. I have long known how earnestly he feels upon this and kindred subjects, and am glad that an association so representative as ours has been privileged to receive the benefit of his deliberation.

Mr. W. D. Robb (G. T. Ry.): Mr. Basford has mentioned

the Grand Trunk and I might describe briefly the system we have adopted. I have realized for some time that the teaching of our employes, and especially our apprentices, for positions of responsibility in the motive power department was a question which could not be neglected, and the system which we have, while it has been in force on the Grank Trunk for a number of years — I went through it when I served my time — latterly dropped into partial disuse: but I found there was a shortage of material: that we ran out of men and I had difficulty in obtaining men for positions of responsibility, difficulty even in obtaining men for good positions as workmen, and I decided that it would be necessary to educate our own men. I therefore introduced the apprenticeship system, starting in with indenture papers. Every boy is indentured. He signs himself and is signed for by his parent or guardian, and these indenture papers prevent the apprentice from joining any union as long as he is serving his apprenticeship. We had considerable difficulty in obtaining apprentices when we started, but after the system became known and the parents realized the benefits which the boys would receive, that difficulty disappeared. For your information I will tell you the number of apprentices we have. At Montreal we have 234 machinists, 90 apprentices, a percentage of 38; at Toronto, 64 machinists, 25 apprentices, a percentage of 39; at Stratford, 289 machinists, 110 apprentices, a percentage of 38; at Fort Gratiot 110 machinists, 60 apprentices, a percentage of 54. We have an average of 40 per cent of apprentices.

At first the system of educating the apprentices was voluntary, that is, the drawing and teaching; but I realized this would not do, inasmuch as I found that the apprentices as a whole were not taking the interest in the classes which was desirable, and it was made compulsory. An apprentice boy is given to understand when he comes in that he has to pass an examination on reading, writing, spelling and arithmetic, in addition to a physical examination. Unless he passes this first examination successfully he cannot enter the service. The schools for teaching drawing, etc., start in October and end in April. The teachers are provided by the company, as are the room, the light and the heating of building, and all the apprentice has to do is to buy his own instruments.

A list of the names of every apprentice in the works is given to the teacher and the roll is called. Every boy who is absent has his name sent to the Master Mechanic, who takes him to task and he has to give a reasonable explanation for non-attendance. If his reason is good it is accepted; if not, he is censured. After that if he does not attend with proper regularity he is discharged. All the increases he is to receive are shown on his indenture papers. We deduct a percentage from his daily rate which is retained by the company until he is out of his time, when all the money that has been deducted from his wages during the five years' apprenticeship is paid back to him together with a bonus. We have found that by having this system of indenture and holding the money back we are able to hold our apprentices, which we formerly could not do. These boys have to pass an examination before they receive their increase. The examination takes place before the shop expert. It includes drawing and all the subjects of the examining system. It is written, and the papers go to the Master Mechanic for his approval, after which they are sent to the Superintendent of Motive Power. If his examination is not satisfactory he is set back for six months and receives no increase; if he fails in his second examination he is discharged. In addition to the teaching of drawing we are now teaching them theoretical and applied mechanics and mathematics. We have no difficulty, as I said before, in getting apprentices for machinists, but we did have difficulty in getting apprentices for boilermakers and blacksmiths and it was necessary to take on young boys and boys who did not have sufficient education to enable them to pass the apprenticeship examinations. We have now introduced a school, along with the drawing and other training, to teach these boys reading, writing and arithmetic, and they come in when younger than the other apprentices. They have to pass these examinations, after which they are allowed to pass the full apprenticeship course.

In the spring of the year at local points prizes are given to the apprentices who are most competent and have shown the greatest proficiency from the instructions received. In addition general prizes are given for which the boys compete over the entire system. I want to say that we are already finding a great deal of benefit from the system introduced; in fact we have

reached a point now where we are able to get sufficient material for promotion on the system without having to go outside for it.

MR. GEORGE W. WEST (N. Y. O. & W. Ry.): Mr. President, I want to endorse Mr. Basford's paper, and to say that we have no trouble in getting apprentices. I think the secret of success of any apprenticeship system is, as Professor Goss says, dependence on the foreman and fairness. We keep one apprentice to five machinists, or five mechanics, and we always have a waiting list of ten or fifteen apprentices waiting to be taken in. Our gang foremen to-day all came up from boys learning the trade in the shop, and our best mechanics to-day are the boys that have learned the trade in our own shop, and they are the most loyal men we have. As a rule they are the sons of old employes who have an interest in the road and in their locality, and we find that it is a paying investment.

MR. J. F. DEEMS (N. Y. C. & H. R. R. R.): Mr. President, I read Mr. Basford's paper somewhat carefully and with a great deal of interest, and I had a copy of it on which I had made some notes on the margin. I left it on the desk here yesterday with some other papers, and they have disappeared, and I am rather at sea without them. I will only say in a general way that it seems to me there is no question to-day confronting the railroads of this country that is so important as work along the lines suggested by the excellent paper by Mr. Basford. I became more convinced of that every day. I do not agree with the gentleman over here who spoke about the boys not wanting to become apprentices. I infer from what he said it is his idea that boys are different now from what they were thirty or forty years ago. I think they are about the same, and I think if the apprenticeship system is devised to make the work attractive to the young men, there will be no difficulty in having all the applicants we want. I do not intend to undertake to go into detail. The paper is so valuable and so full of good suggestion from beginning to end that I think we can accept it as a whole as one of the very best and most valuable contributions we have had in a long time. I can only say, as I said in the beginning, that it seems to me there is no question to-day confronting the railroads of this country that is so important in all its bearings and ramifications as

this question of the proper education of the employes of the railroads, and I know that some important lines are already taking action. Just what the outcome will be I am not quite certain. I hope, however, that it will be the establishment of some proper apprenticeship systems, accompanied by educational facilities, if you see fit to separate one from the other, which really you can not do, and I am looking forward with a good deal of satisfaction to the outcome of these schemes that are now being considered. I feel sure that it will be attended with very good results.

MR. GEORGE E. PARKS (Mich. Cent. R. R.): Mr. President, I might speak of the system in use on the Michigan Central. For the past twenty years — I think it is about twenty years — they have conducted night schools which have been held six months in the year, wherein apprentices were taught mechanical drawing. This included not only apprentice boys, but the sons of employes who wished to take advantage of the work. Mechanical drawing is taught in the schools at the locomotive shops, and both free-hand and mechanical drawing are taught in the schools at the car shop. At the end of each term the drawings are examined by the instructors and prizes given. We have found that the attendance has been satisfactory. The boys become very much interested in the work and seem to feel an appreciation of what the company has attempted in their behalf. I think this is one method of teaching mechanical drawing which not only helps the boys to work for the company, but helps them in case they should take another position.

MR. J. F. WALSH (C. & O. Ry.): Mr. President, on my way over here I found time to read Mr. Basford's paper, with a number of others, and it appealed to me as being so full of good horse sense that at my first opportunity here I hunted up Mr. Basford to express my opinion on those lines. I can not see what now is necessary for us to do beyond organizing at the more important points something in the way of a school for our apprentices, giving them, out of the working hours, I would say, preferably, an hour or two a day. We find no difficulty whatever in getting all the apprentices we need, and I may say that that applies to all classes of labor, but it especially applies to machinists' apprentices. We use, as a rule, the sons of our old employes — engi-

neers, conductors, machinists, blacksmiths, etc. To attract boilermaker apprentices to us we give them a better rate to start with and we raise their pay every six months, and we do not find any very great difficulty in getting boilermaker apprentices. But to get closer to the apprentice, to make the apprentice feel that he is part of our official family, I believe it would be money well invested to organize this school system and give them the schooling out of the ordinary working hours. We have not been as smart in looking after our own interests as many of our journeymen organizations have been in looking after theirs so far as our apprentices are concerned. They have recently arranged to take the apprentice in with them as a part of their organization, so as to get them more thoroughly under their wing, and it seems to me that we have been too slow in this matter, and that the time is ripe now for taking up the question of the education of our apprentices on the lines suggested by our friend Mr. Basford.

MR. E. A. MILLER (N. Y. C. & St. L. Ry.): Mr. President, this question is almost as old with the Master Mechanics' Association as the Association itself. At any rate, for the last ten or fifteen years, it has come up as one of the questions to demand our consideration, and after all these years of consideration we find it just as important, and I think hardly any better solved to-day than it was when first presented. The conditions over the country have a very important bearing on the apprentice system. For instance, I think it was the general experience four or five years ago, when an unusual demand came for railroad mechanics, machinists especially, and in all departments, there was, as you know, an unusual demand for mechanics. It was so with us and I think with a great many railroads, that the apprentices could not be held in the shops.

I am very glad to see the system of a bonus or premium being held for those boys, or apprentices, who serve their time, for the reason that too frequently the apprentices will leave for the inducements that are held out to them in other shops. I think officials are not careful enough in noting whether the young men coming to them have finished their apprenticeship before they started out. I know of Master Mechanics who have taken apprentices from our shops and put them in at full journeymen's

pay when they had only served about two years of their apprenticeship. This is wrong with the officials, to start with, and it encourages apprentices in leaving their home shops.

I want to express my satisfaction with the paper that Mr. Basford has given us, which is the best, in my judgment, we have ever had presented to the Master Mechanics' Association. Turning to page 5, I heartily agree with him that the first important step is to select boys of intelligence, of good moral character, of good physique; boys that we have every reason to believe will grow into strong, competent, bright, intelligent mechanics. I think that is the first thing. I believe with a full understanding that boys who are improving their opportunities for technical education will be given preference when selecting apprentices will bring out from the helpers and young men in the shops many who can be put in as apprentices. While I was Master Mechanic — and other Master Mechanics I presume are following the same rule — we filed the reports that came to us from the correspondence schools in which the young men of our shops were taking a course of study. We have quite a number of boys who are anxious to go in as apprentices, who are taking a correspondence school course, and it is understood that those boys will have the preference. I believe fully, with Mr. Basford, that it is right to put every boy on an equal footing and promote him according to what he accomplishes. Through that means any young man coming into the shops understands that his opportunity is just as good as the prize boy coming from a technical school. Put them in, put them on their merits and advance them according to their ability. [Applause.]

MR. W. D. ROBB (G. T. Ry.): Mr. Chairman, I should have mentioned that when we put the boys in the shop, although we give them this training, the same interest is followed up in the works. A report goes to the Master Mechanic each week showing the percentage of marks each boy has obtained for attention to his work, general conduct, etc. If it is not satisfactory he is taken to task the following Monday and given to understand that his conduct will not be permitted. He is continually coached that he must endeavor to excel. This goes on throughout the entire apprenticeship course.

I should also have mentioned that in addition to the apprenticeship system we also have an arrangement — both the Canadian Pacific and the Grand Trunk — with McGill University, whereby we take on special apprentices during their vacation. They come to us and we put them through the different shops for three years, and at the end of that time, when they have finished their university course they take an additional two years in the shops. I agree with Mr. Deems that there is no question or subject in the motive power department to-day more important than the education of its employes, and not only does this apply to apprentices but also to engineers and firemen. On the old basis of promotion a fireman would fire from five to ten years before being promoted to engineer, but where of late years promotion has been so fast he is required to put about ten years' experience into about three years. You can give a fireman all the literature on the locomotive that you like, including an air-brake book, but with the majority of them it is a waste of time. They have so much to do in attending to their duties that they have not time to read this literature or to study it, and then when wanted in a hurry for examination and promotion they are not prepared.

At the present time the apprenticeship system has brought out another system, which is going into force. Firemen when they come on are examined physically as well as on different subjects, and are given to understand that at the end of six months (firemen are on probation for that time) they will have to pass another examination. They are told the lines along which they will be examined. The first examination is not severe. They are taken right from the start and not allowed to go on without instructions until called upon to pass as engineers, but are examined each year for three years. By following out this course, giving them to understand they have to pass these examinations, just the same as the air-brake examination, it is surprising what advancement the fireman makes, and instead of having to turn down a large percentage at the end of the third year the majority pass successfully owing to the education and the course of training they have received.

Mr. L. R. Johnson (Canadian Pacific Ry.): I would like

very much indeed to add my voice in congratulating Mr. Basford on the excellent paper which he has presented to us this morning and also to express my appreciation of the way in which he has handled the different details connected with the scheme which he has discussed. The different details of this proposition may not probably suit each one of the gentlemen present. We will all have to work out the details to suit the individual circumstances connected with our own roads, but he has certainly laid down for us a line of thought from which we can deduce our own details, and I think has done so in a very admirable manner. Mr. Gaines, a little while ago, suggested that in dealing with the different points raised by Mr. Basford it would be better perhaps before cooking your hare to catch him. I would like to say by way of amendment that before catching your hare you must know that there are hares to catch. I do not for one moment wish to throw out the insinuation that the nation to-day is not supplying boys who are full of ardor and enthusiasm and anxious to go into the railroad service, because those of us who are at the head or near the head of the different motive power departments of our large railways know from experience that our office has always a continuous stream of boys coming along and making application to be allowed the privilege of going into the shops to become apprentices for eventually becoming railway engineers. But leaving on one side the question of our special apprentices and our technical graduates, I think that the stream of boys going through our office, making application for apprenticeship, may be divided into two classes. First of all, there is the uneducated boy, or the boy with very little education. He comes there merely with an idea of becoming eventually a workshop mechanic. His ideas do not branch off, or carry him any further ahead than that. He wants to be able to use his tools, and earn a good wage by working on a bench, at the pits, or on a machine. But those boys are not the ones whom it is proposed to treat in the way proposed in Mr. Basford's paper. Of course, we will all know that amongst that large crowd — and I think from my experience they are in the majority amongst the boys who are making application for apprenticeships, the poorly educated or almost entirely uneducated boys — that amongst that large number there are notable exceptions which

prove the rule; that is, boys who have talent inborn in them, whom no power on earth can keep down no matter what position we put them into in the shop, no matter how much there may be against their getting ahead or being helped ahead. Nothing you can throw in their way will keep them down. But such a boy is an exception, as I say, and it is only to be regretted that there has not been, up to the time that he makes his application, an opportunity for his getting the education necessary to make him capable of going ahead and filling the position that he should occupy with credit to himself and satisfaction also to himself. Of course we know very well that the class of boys I have just spoken of could not possibly fill the positions that motive power superintendents are called on to fill to-day and handle the different subjects that they have to handle. But on the other hand there is the other class of boy that comes along, and that is the boy who has been well educated, and I must say that, although perhaps not quite so numerous as the other class of boys, there are quite a number of these boys coming along looking to work their way into the railway world some day. Now, here I think we strike the note which gives us the cause for such a paper and such suggestions as have been made to-day, and that is, why do not these boys that come along, educated boys, why do they not come forward and fill the positions which we are complaining to-day we have not the material to fill?

Now, there are different reasons for this. One of them at any rate is the fact that a boy when he has had a good education, in nine cases out of ten can go out into the world and earn his living, a better living probably than the boy who comes into the shops for a few years; and I think it is the tendency to-day, all over our continent at any rate, to deal with the present and not to look ahead for what is coming in the future, and therefore our boys are falling into the same habit as we ourselves are, of dealing with the present, and rather than take hold of something to-day that will necessitate a few years of hard work, of drudgery and so on, with very small pay, they probably prefer to go out into commercial life, where with their ability and education they can earn a good living straight off. I think that the propositions set forth in Mr. Basford's paper may meet this very trouble by introducing

into our shops or into the course of study necessary for our apprentices sufficient technical education, so to speak, for these educated boys, because they have the groundwork of their education, and make the apprenticeships in our shops and on our railways interesting enough to keep this second class of boys with us. If we can do that I think by all manner of means it is worth our while to spend a lot of time and a lot of thought on this very subject of making it interesting, so that we can keep those boys in the ranks and gradually train them to fill higher positions which every one of us appears to agree it is difficult to find material to fill. I think that Mr. Basford has certainly struck the right note in recommending that we make our apprenticeship courses instructive and interesting in order to cover a great deal of the drudgery which it is not to the liking of our well-educated boys to follow through.

MR. W. E. SYMONS (K. C. So.): I think Mr. Basford's paper is a very excellent one, and should have the endorsement of this Association. In addition to that I think each member of this Association should constitute himself a committee of one, when he gets home, to talk to his general manager or president in reference to wages paid to foremen, Master Mechanics and other subordinate officers in the mechanical department. One reason we do not have more apprentices, and get better results from them is because the situation is not sufficiently inviting. We have many instances of foremen occupying positions at $60 to $80 per month, and Master Mechanics at a proportionately higher rate, who should receive from thirty to fifty per cent, and sometimes possibly one hundred per cent more.

Men do not select as a calling or life work a business which involves much study, years of hardship, and sometimes of privation, to fit himself for, that when he secures it, the compensation is not equal to, in many instances, that of a journeyman machinist, locomotive engineer, or train dispatcher, or men engaged in the ordinary industrial walks of life.

I think as a class we have been somewhat remiss in not talking more favorably to the management of the roads about underpaid foremen and Master Mechanics, when if we had given this a little more attention the position of foreman, Master Mechanic, Super-

intendent of Machinery and other similar positions, would have been more inviting, we would have had a better class of apprentices with plenty of applicants awaiting enlistment, and would require less rules and regulations to govern and control them, not only during their apprenticeship, but after it is completed.

MR. T. E. ADAMS (St. L. S.-W.): In the last part of the paragraph on page 6, the paper reads: "Engineers and firemen should be educated to do their best, and it is important to bear in mind that the difference between the work of the best and of the average man represents more to the road than the economies to be obtained from the best fuel-saving appliances or invention ever brought out."

I wish to say in that connection in listening to the discussion of this paper it has occurred to me that fact should be brought out more strongly than it has been. There is nothing in the country to-day in the operation of railroads that is of more interest than the question of fuel. The education of the engineer and the fireman in the use of fuel is one that does away with the setting out of trains, engines failing on the road, delays on cinder pits, cleaning fires, etc. It has been demonstrated beyond a reasonable doubt that the excuse of an engine failing on the road because of poor fuel is not tenable, from the fact that there is not any fuel used in the country to-day, if properly used, will clinker, and I believe the word clinker is not the proper word to be used in connection with the cinder pit; it should be ash. As a matter of fact, if the coal is properly burned there will be no clinker. We all agree where our trains are delayed from two to three hours, as the case may be, on account of engines not steaming, poor coal, etc., it is a serious difficulty to the management, as well as a source of annoyance to the motive power officials.

On our road we take into consideration the education of the engineer and fireman in the fuel question. We adopted a method under which, if the engine loses any time on the road due to the engine not steaming, we bring the engineer and fireman into the office and ask them the cause. If the statement is made that it was on account of poor fuel, we ask him to explain what he intends us to understand when he says poor fuel, and in that manner we bring out his idea of it and instruct him accordingly. It has had

a wonderful effect. We run our 20 by 26 inch switch engines four days and nights without cleaning the fires, cleaning the ashpans once in twelve hours, and when the fires are cleaned at the expiration of this time it can be done in fifteen minutes. We have run a 20 by 26 inch engine in freight service 250 miles with Illinois coal and have not shaken the grates or cleaned the ashpan. The engine was in service thirty-five hours on a turn-around trip and at the expiration of same the fire was cleaned in fifteen minutes.

I believe to-day that one of the most important subjects for this convention to consider is the intelligent use of fuel, not the economical use of fuel, because intelligent use of fuel results in economy. I do not believe there is any foundation for the statement of poor coal, and I do not believe the man who makes the statement can prove what he says when he does say it. It seems to me it would be a good thing for this convention to go further in the subject treated upon in Mr. Basford's paper and to appoint a committee whose duty it would be to draw up a plan of education of engineers and firemen in the use of fuel for the purpose of doing away with delays of trains from this particular cause.

MR. S. W. MILLER (Penna. Lines): There are two points in this paper on which I would like to say a few words, one of which has only been lightly touched on by the speakers and the other one not at all. According to law, as I understand it, it is not necessary for a man to make any statement which will incriminate him, but I might as well admit now, as it may be found out later, that I had the misfortune to be a special apprentice. The paper demonstrates clearly that Mr. Basford does not believe in special apprentices. He says that it is a serious mistake, and that for twenty years the railroads have made this mistake. I do not agree with him, because I know of too many successful railroad officials who have been promoted from the special apprentice rank, through the special apprentice course. But I want to say that they were not made superintendents of motive power in three years. And I think that is where those who feel that the special apprentice system is the solution of the trouble we are experiencing in getting competent men to fill the higher positions, make their mistake. You would not expect to make a mechanic by a

four years' course of apprenticeship in a shop. All that that period of service does is to give the young man in whatever department he may be a general idea of the use of tools, of the principles to be followed, of the shop practices, and of acquaintance with his fellowmen. His later experiences make the man of him who is fit to be called a mechanic, and it is the same way with the special apprentice.

I do not believe that ten years on an average is any too long for a young man to serve a special apprentice course — I think his course in the shop should be just as long as that of an ordinary apprentice. I do know of cases which have come under my personal observation, young men who have been sent to the shops over which I had jurisdiction, who made flat failures of themselves, and the reason was that they felt that their education which they had received at college made them, not better educated boys, but better boys; between the two statements there being a serious difference.

The other point on which I want to touch is a statement that Mr. Basford makes on the bottom of page 3: "The general manager once knew all of his subordinate officials, because they were few and changes were not frequent. He once knew all of his Master Mechanics, station agents, conductors, engineers, dispatchers and even telegraph operators. They knew him and were working for him, because he was personally close to them in their work. All this has changed as the roads themselves became greater, and as roads great in themselves combined into systems, as has never been done anywhere else in the world. With this change the officials have by a powerful current been carried far from the men in the ranks, and far even from their subordinate officials. From personal friends the men have become to them as mere numbers." I think that is one of the most important statements in this very valuable paper. I do not believe that we realize how the men feel about these things. I do not believe that it is generally appreciated that just as soon as a man is selected from the ranks and made a foreman there is an invisible barrier between him and the men who were formerly his shop mates. It is almost the same as if a brick wall had been built up between them. He does not associate with the men any more and frequently feels that

he is somewhat better than they, and his wife will not call upon their wives, and his children will not walk to school with their children. As that goes up the line, and it gets to the general foreman or Master Mechanic, the wall becomes higher and it becomes thicker, and it becomes more difficult to discover just exactly how the men feel about things. I believe it is the most important duty of a Master Mechanic in charge of a shop to be fully in touch with his men and to know, not from hearsay or through the foreman, or any other outside source of information, but to learn from the men themselves personally how they feel about matters which are going on in the shop.

I have found it of the greatest assistance to me in my work to know the men personally. I had ocasion the other day in thinking about this matter to count up how many of the men in the shop, of which I am now Master Mechanic, I personally knew — those whom I could call by name, and whom I was in the habit of calling by their first name. We have two thousand men, and I found that I knew slightly over thirty-three per cent. I do not feel that that is enough. I would like to know every one of them. In thinking about the subject matter of this report it occurred to me that I would like to know how the men and the foreman feel about the special apprentice question, and I addressed a letter to 107 of the men and to the ninety-two assistant foremen and gang foremen whom we have, and asked them for their views, promising I would not make public their opinion, but wanted them to say exactly how they felt about it, their personal views. I assure you that the reading of the letters from these men was a treat to me. It shows me that the American mechanic to-day, and not only the mechanic, because I addressed the letter to men in the labor gangs also, think about this apprentice system. I am also free to say to you that the men believe that the Master Mechanic should know what is going on in the shop, and that every one, without exception, says that the Master Mechanic should personally know as many men in the shop as it is possible for him to get acquainted with. I feel that the failure to do this is one of the reasons why we have troubles. We do not get close enough to the men. If each one of us had only twenty men to take care of, I guarantee there would be no necessity for trouble

because we would know what each man thought of certain things and be able to correct his views in the cases in which he was wrong, and we would also be able to show him our side of the question. We would make him understand that we were trying to do what was right for him, and trying to be fair and just to him, trying to advance his interests and at the same time not prejudice those of the company; we would convince him that we were trying to make him a better man and a better citizen of these United States, and that we were desirous of doing everything, not only for our own personal interests, but for his, knowing that on the condition in which the man finds himself and on his desire to help his Master Mechanic or foreman, the success of the Master Mechanic or foreman almost entirely depends.

MR. E. A. MILLER (N. Y. C. & St. L. Ry.): I want to emphasize before this convention the necessity of a technical education for the railroad official of the present day and the coming day. But there are many factors that enter into the conditions that a young man has to meet when he takes charge as a foreman; there is a great deal that he must be qualified for besides the technical part of the work.

THE PRESIDENT: If there is no further discussion we will ask Mr. Basford to close the discussion on the report.

MR. BASFORD: It is impossible for me to express the gratification I feel at the manner in which this paper has been received. The hour is too late to take up in detail the very important remarks made by the various speakers, although I would very much like to take them up in detail if I could. It is often said that in the strife for success all depends on the man. That is only partly true. Some men can not be kept down and they will rise as they have always risen, in spite of all difficulties.

This paper is a protest against artificial difficulties which are placed in the path of the rank and file and a plea for that which will aid and encourage men to rise as high as each individual is capable of going. I beg you to bear in mind a pyramid — a pyramid of the rank and file, the rank and file of workmen upon whose shoulders you stand. As the base is great and upright and strong morally and intellectually, so is the structure. No structure is great and permanent that is not right at the bottom. We

need to make apprenticeship attractive; foremanship also. Boys can not now afford to be apprentices and good workmen can not afford to be foremen. I think you will probably all agree with the third paragraph on page 9 in the paper in which I say: "The condition and position of the superintendent of motive power should be elevated and improved, so that young men will see that they can afford to spend their lives preparing for higher positions. They will then be impressed with the fact that to secure such a position is worth a lifetime of conscientious and unwavering effort. This is not the case to-day."

PROF. W. F. M. GOSS: I move that the discussion be closed, and that the thanks of the Association be tendered to Mr. Basford for his interesting and valuable paper. (The motion was seconded and carried.)

THE PRESIDENT: If there be no objections we will now take up the report of the Committee on Flexible Stay Bolts, and as the Chairman is not present I will ask the Secretary to read it.

The Secretary presented the following report:

REPORT OF COMMITTEE ON FLEXIBLE STAY BOLTS.

To the Members:

The Committee on Flexible Stay Bolts wishes to report progress, but finds itself unable to present at this meeting as complete a report as it desires. The failure to present the report is caused by the undertaking of your committee of some rather extensive experiments in connection with the question under consideration, which, due to unavoidable delays, could not be completed in time; some preliminary tests, however, show that the final results would be of great interest, if not great value, and so rather than discontinue these tests and feel that an incomplete report had been presented, the committee would ask that it be continued for another year.

R. N. DURBOROW, *Chairman,*
F. M. WHYTE,
C. E. FULLER,
O. H. REYNOLDS,
Committee.

THE SECRETARY: I make a motion that this report be received and referred to the Executive Committee to consider when it meets to formulate a program for the next convention. (The motion was seconded and carried.)

The meeting then adjourned until Friday morning.

FRIDAY'S SESSION.

The President called the meeting to order at 9:50 A.M.

THE PRESIDENT: The first order of business is the report of the Committee on Water Softening for Locomotive Use. As the Chairman and other members of the committee are not here, the Secretary will read the report.

The Secretary read the report of the committee:

REPORT OF COMMITTEE ON WATER SOFTENING FOR LOCOMOTIVE USE.

To the Members:

There are two classes of waters commonly used for locomotives — scale-forming and alkaline. In both the impurities remain in the boiler either to form an accumulating scale or a concentrating alkaline solution, or both. The scale-forming material can either be removed from the water by heat or by chemical means. There is no known means of removing the alkali. The advantages of supplying a boiler with a clean water practically free from scale-forming material is shown by the boiler records of roads fortunate in having first-class water supplies, where fire-boxes last almost indefinitely and flues are reset only when the beads are worn off.

Treatment of water in the boiler with boiler purges.

The first attempt at water purification and general railroad practice in this country was to use a boiler purge — soda-ash or some allied sodium salt — generally put into the locomotive tank. This process precipitated the scale-forming material in the boiler as mud and also tended to loosen up the scale already formed in the boiler, but it did not lessen the number of necessary wash-outs to any extent and required frequent blowing off, which did not effectually remove the mud, and, in addition, there was an accumulation of alkali in the water in the boiler not easily controlled. Theoretically a boiler purge for purifying water in the boiler was nearly perfect, but practically it was not so successful. Treatment of water in the boiler has the advantage of being cheap, and that is all.

In order to obtain the pure water condition of a few of our fortunate neighbors, the practice of purifying the water before it enters the boiler has come into extensive use. The lime and soda-ash treatment has been used in some form or other for a great many years, but the mechanical devices for making the process successful, as well as economical, are of recent origin.

Treatment of water before entering the boiler.

It is not the province of this committee to discuss the merits or demerits of the various mechanical devices on the market; further than to say, that they all work on one principle, namely, use enough soda-ash

(sodium carbonate) to precipitate the sulphates of calcium and magnesium as carbonates, and enough slaked lime (calcium hydrate) to neutralize the carbonic acid existing as free carbonate and bicarbonate, precipitating all of the carbonates of lime and magnesia in the water and also precipitate as carbonate all of the hydrate of lime added in the treatment process. The process is theoretically perfect and in practice leaves so little scale-forming material in the water that the beneficial results are most apparent.

There are two systems of treating waters; the continuous and intermittent.

Continuous system of treatment.

The continuous system consists of a device for mixing the required quantity of slaked lime and soda-ash in the water as it flows into a receptacle of such size that the slow flow of the water permits the precipitated scale-forming material to settle out, delivering continuously the purified water.

Some continuous processes apply a filter to make sure that the sediment is removed from the water. This is believed to be a valuable addition to any plant where such a filtering process would be considered an addition. The advantage of the continuous process is that it takes up a minimum ground space.

Intermittent system of treatm

The intermittent system consists of treating the water and letting it settle and pumping the purified water from the top of the settling reservoir, using a floating intake pipe. The advantage of this system is low first cost.

The settling process requires agitating machinery and time, and a settling plant can not be forced beyond its capacity without jeopardizing the quality of the purified water.

In both systems the cost of chemicals is the same for a given water. The labor cost ought to be the same, if the men doing the pumping can be located so they can attend to the filter as well as the pumps.

Muddy waters are easily cleared of the greater part of the suspended matter, but it is almost impossible to render them absolutely clear unless a coagulant, ferric hydrates or alumina, is used. The slight murkiness in treated muddy water is not seriously objectionable, however.

Filtering.

Filtering plants are more complicated and more expensive than either the continuous or intermittent systems and usually depend upon a partial settling in order to relieve the filters from becoming quickly clogged. They deliver the cleanest water of any of the purifying processes, but it is a question whether the water is enough better to warrant the increased cost.

Quality of wat which can be cessfully treate

The quality of waters which can be treated successfully and with great benefit to locomotive boilers are those which may contain mud, sulphates of lime and magnesia, and carbonates of lime and magnesia, or which may contain salts of iron and free acid. Many alkali waters contain large quantities of incrusting solid. These can be removed, but

the alkali remains and increases by the amount of soda-ash used. If the water is high in alkali, it will give trouble from foaming, and the probability is that it will be more economical to hunt up a better supply somewhere else that can be treated successfully. The results obtained from the treatment of dolomite waters are entirely successful, resulting in better steaming engines, greater tonnage hauled and a marked reduction in engine failures from leaking flues.

Analyses of waters containing from 5½ to 60 grains of incrusting solids per gallon show reduction by the treatment ranging from 3 to 5 grains of incrusting solids per gallon.

Alkali water.

Alkali waters are those containing salts of sodium and potassium in solution, and there is no known chemical means of removing these salts. There are a number of articles on the market which claim to relieve troubles from foaming with alkali waters and some of them are partially successful. It is not, however, the province of this committee to discuss their merits or demerits.

The only way to get rid of alkali is to remove the water from the alkali. This can be accomplished by distillation, but up to the present time the cost of plant and comparatively high cost of product make the process prohibitive for railroad use.

Cost of treatment.

A purifying plant, 500,000-gallon capacity daily, can be erected for from $6,000 to $10,000, according to the process used, and the water successfully treated for scale-forming material, for from ¾ cent to 4 cents per 1,000 gallons, depending upon the quality of the water.

Result of purified water.

By the use of pure water, boiler troubles are reduced to a minimum. One railroad reports that the number of trains abandoned account leaky flues was reduced from twenty-seven to two in a stated period. Another reports that passenger trains delayed account leaky flues on a division using purified water have been reduced from twelve to fifteen per month, to one and two, and an occasional month with no failures. A road handling sixty engines per day has reduced its boiler-maker force from four men to two men — one day and one night — and these men have to be given machinist work to keep them busy.

Committee recommendations.

Your committee does not recommend the use of compounds to be introduced into the boiler where there is a possibility of purifying the water before it reaches the boiler.

Your committee believes that the cost of purifying water for locomotive use is more than saved by the reduction in the labor cost of caring for boilers in the roundhouse, and the benefit gained by freedom from leaky flues and poorly steaming engines on the road is all profit.

J. A. CARNEY, Chairman,
L. H. TURNER,
F. N. RISTEEN,
J. F. DUNN,
ROBERT QUAYLE,

W. BURLINGTON, IOWA, May 30, 1905. *Committee.*

THE SECRETARY: Mr. Carney, the Chairman, is unable to be here this morning. In talking with Mr. Dunn, one of the members of the committee, this morning, he says that he has under way some experiments on water purification, and suggested the advisability of this committee being continued another year, as he believes the results to be obtained from the experiments he has under consideration will be of interest.

C. A. SELEY (C. R. I. & P.): Mr. President, I move that the report be received and that the committee be continued another year, not in the way of shutting off any discussion at the present time, but to have this committee for another year. (The motion was carried.)

THE PRESIDENT: This is one of the most important subjects we have; if anybody wants to discuss the paper, it is in order. The discussion may bring out some information for the committee to work on in its next report.

MR. A. E. MANCHESTER (C. M. & St. P. Ry.): Mr. President, the committee in its report says that it does not approve of the introduction of chemicals into the boiler direct. My judgment in that is that there is nothing as useful and beneficial to the service as a good water softening plant in which water practically soft and free from lime or alkali salts is delivered to the engine and boiler, but any railroads that have to deal with lime salts of any description, or alkalis, would do well to treat their water in the boilers, preparatory at least to the time when they shall be able to have the water plants in full operation on their system. The water softening plants now in operation, and there are a great many of them, have taken hold of what we consider in the West as fair waters. I have not known of their undertaking to treat very many of the bad waters. There is a large area of country in the Dakotas, Kansas, Nebraska and the West, where only bad waters are to be handled, and I hope that during this discussion the question of how to treat alkali waters and those that we have not been able to handle heretofore, may be given a very thorough consideration. As I have already said, there is a great deal of territory in which we have to handle waters that have the alkali in them, or have both the alkali and the lime salts, in many cases the lime salts so high that treatment by the Clark process adds

to the alkali already in the water and gets a concentration of alkali so high that it is not usable. I believe that in so far as laboratory tests are concerned there have been many successful treatments made with barium carbonates. I would like to hear from any one who has gone far enough into the barium carbonate treatment to say whether the process is satisfactory, whether they are able to get the desired results so far as quality of water is concerned, if they have been able to get barium carbonates of a fixed value, and if the cost of this treatment has been found to be prohibitive.

MR. E. W. PRATT (C. & N.-W. Ry.): Mr. President and Gentlemen, on many of the branch lines of the Chicago & North-Western Ry. we have to use water such as is referred to by Mr. Manchester, particularly water with a great deal of encrusting matter. In Nebraska, Dakota and Wyoming, we fortunately avoid the alkaline water, but have water with a great deal of lime salts. I want to emphasize what he said, from my personal experience, that it is better to treat water in boilers than not to treat it at all; and to corroborate that idea I can say that we have practically doubled the life of flues and fireboxes in some of these poor water districts by adding blow-off cocks, using soda ash, increasing the facilities and pressure for washing out boilers and following up the whole matter to see that instructions are carried out.

MR. J. F. WALSH (C. & O. Ry.): Mr. President, our experience has been very much like that just spoken of by the gentleman who preceded me. On one of our coal branches we installed last fall a water purifying plant. Up to the time of the installation of that plant it was an utter impossibility to run those engines more than three or four days without holding them in both to calk the flue and the boiler generally, and to wash the boiler. After the installation of the water softening plant, we find that we can run those engines, with a little bit of care in the matter of blowing off, by installing an extra blow-off cock on the engine — we find we can run those engines for thirty days without holding them in or washing them out. On account of the expense we have not up to date been able to get any further water purifying plants installed. There are two places on our system where we have been treating the water in the boilers, and to illustrate what

we have gained even by that, take four engines of the same class, all heavy passenger engines, running over identically the same territory, and using a so-called boiler compound in three of them, and no boiler compound in the other engine, we find that we can run from two to three times as long without having any flue trouble with the engines in which we use the boiler compound as we can with the one in which we do not use it; and this particular engine is in the hands of a very competent, careful man. I believe the points made by the gentlemen are very well taken, that it is well worthy our attention, if we cannot afford to put in a purifying plant, to adopt some means of treating the water in the boilers.

We have another case of a switching engine located at a point where we get water that is very highly impregnated with impurities, that we had to take to the terminal some forty miles distant, oftentimes twice a week, and send a boilermaker out between times to calk that engine. We have run her as high as three months without putting a calking tool on her, just by a little careful treatment of the water in the tank before putting it in the boiler.

MR. J. F. DEEMS (N. Y. C. & H. R. R. R.): Mr. President, there is a matter coming up in the near future which will be interesting to railroad men. A plant will probably be installed on the Big Four Road within the next four to six months for purifying water by electricity. The firm that will install the plant has been for many years in the business of purifying water for drinking purposes and has been very successful. They agree to put the plant in at their own expense — it will probably cost them, being the first plant, a matter of $15,000, tested out thoroughly for purifying 250,000 gallons of water a day — and if not successful they will take it away and it won't cost a cent; so they seem to be very confident as to what they can do. This system would have, if it is carried out as they anticipate, some advantages over chemical treatment. The difficulty about treating water chemically in the tank is the fact that in treating water from streams and surface reservoirs the condition of the water changes very often and sometimes very quickly, and it is not possible to follow it properly, and if you put in enough chemicals to do the work when the water is in its worst condition, you have altogether too much

at other times. They claim that with their system you can regulate the current to purify the water in its worst condition, and no bad effects will result when the water is in its best condition and they think they can purify it somewhat cheaper than by any of the other systems now in use. Of course, I do not know what the results will be. I just mention that as a matter of interest to members.

THE PRESIDENT: Are there any other remarks on the purification of water? If not we will take up the next subject. (On motion, the discussion was closed.)

THE PRESIDENT: We will now take up the report of the Committee on Time Service of Locomotives, Mr. William Forsyth, Chairman.

Mr. Forsyth presented the paper as follows:

REPORT OF COMMITTEE ON THE TIME SERVICE OF LOCOMOTIVES.

To the Members:

Your committee finds in the replies to its circular of inquiry that the information varies so widely, covers so short a period of time, and for most roads includes so few engines, that no definite conclusions can be drawn as to the percentage of time locomotives are "in service," "at terminals ready for service," "held for roundhouse repairs," etc. It is apparent also that different interpretations have been made of the several divisions of the total time by different reporters.

To obtain more accurate information the committee recommends assigning an apprentice or clerk to each roundhouse to record for each engine the "time of arrival at roundhouse tracks," "time put into house," "time ready for service," "time departed from roundhouse tracks." It also recommends that engineers be required to make a trip report showing "time departed from terminal," "time for all delays and stops," and cause, "time switching" and "time arriving at terminal."

The committee is of the opinion that such information will show that the greatest opportunities for increasing the mileage of engines lie in reducing the delays in service and not in rushing them through roundhouses more rapidly.

It is worthy of note that the reports for time "in road service" plus the time "held at terminals ready for service" are fairly constant between seventy and seventy-five per cent. One road gives this figure for freight engines, accurately obtained by having special observers follow certain engines for a month, at seventy-seven per cent.

It is reasonable to conclude from the tabulated reports that engines are ordinarily in the hands of or at the disposal of the transportation department three-fourths of the time, and this department is responsible for the large proportion of delays which so materially limit the mileage at present obtained from locomotives.

In order to obtain definite information in detail, it would be advisable to obtain accurate records at each large terminal for at least one engine in each representative run, and to do this a man must be especially assigned to the engine and keep accurate record of the time of all its movements.

To show the detail into which such a report can be divided, an actual record is here given of the complete time service of one locomotive for one month in freight service. It will be seen that the total time in the hands of the motive power department was 22.6 per cent, and in the transportation department 77.4 per cent, and that the delay due to motive power while on the road constituted but 1.9 per cent of the total time. The average running speed was 15.2 miles per hour, but the total mileage, divided by the time in the hands of the transportation department, is equivalent to only 5.7 miles per hour, and the average equivalent speed for the total time of test 4.4 per hour.

Your committee is of the opinion that records relating to the time service of locomotives are worth keeping in considerable detail and that numerous delays can be checked up in this way which do not appear to be noticed or obtained by ordinary methods.

It is believed that the object sought by the appointment of the committee has been realized by the figures here presented, and it only remains for railroads to obtain for themselves similar information relating to their own equipment and service in as complete detail as they may find profitable.

It is apparent that comparisons of the services between different railroads can not serve any very useful purpose, except to show that one may be very good, while the other quite bad. Your committee therefore presents these figures and suggestions, and requests that the committee be discharged.

WM. FORSYTH,
HENRY BARTLETT,
J. S. CHAMBERS,
DAVID VAN ALSTYNE,
Committee.

CHICAGO, May 18, 1905.

TABLE 1.—TIME SERVICE OF LOCOMOTIVES, ON VARIOUS RAILROADS.

NAME OF RAILROAD.	PERCENTAGE OF TOTAL TIME—100 PER CENT.					
	On the line in Service.	At Terminal Ready for Service.	Held for Roundhouse Repairs.		Shopping.	
			Heavy.	Light.	Held Waiting.	Under Repairs.
C. B. & Q. lines east of Mo. River—Average of 445 locomotives	32.	57.	.....	.....	.....	11.
C. B. & Q. lines west of Mo. River—Average of 5 locomotives	23.9	47.7	.....	28.4	.....	.....
C. B. & Q. lines west of Mo. River—Average for 11 heavy locomotives	35.6	40.3	.....	24.1	.....	.....
Lehigh Valley—Average for 12 locomotives. E. & C. Branch Auburn Division	33.	53.	3.	8.	.....	3.
Lehigh Valley—Average for 20 locomotives	67.	2.	3.	4.	6.	18.
Union Pacific. Wyoming Division—Average for 32 locomotives	45.7	18.4	6.3	11.7	5.3	12.6
Union Pacific. Nebraska Division—Average for 147 locomotives	46.	28.	4.	10.	2.	10.
Southern Pacific. Pacific System —Average for 297 light locomotives. Month of January	21.75	46.25	5.	7.	5.	15.
Southern Pacific. Pacific System—Average for 415 locomotives weighing over 100,000 lbs	24.	36.	3.3	10.7	4.	22.
Southern Pacific. Salt Lake Div.—Average for 40 locomotives	58.	20.	2.	10.5	.....	9.5
Oregon Short Line—Average for 156 locomotives	40.	47.	3.	.....	.....	10.
Boston & Maine—Average for 44 locomotives. Heavy and light. All classes of service; 3 months	52.4	38.9	1.3	2.8	0.6	4.0
Boston & Maine—Average for 422 locomotives. One year	.....	.....	.....	.....	2.7	6.6
Grand Rapids & Indiana Ry.—Average for 18 locomotives, weighing over 100,000 lbs., one month	61.8	12.4	.....	16.7	.....	9.1
Grand Rapids & Indiana Ry.—Average for 19 locomotives, weighing under 100,000 lbs., one month	57.6	16.	.....	14.5	.....	11.9
Chicago, Indianapolis & Louisville R. R.—Average for 99 locomotives	47.85	34.37	2.46	7.71	0.19	7.42
C. I. & L. R. R.—Average for 41 light locomotives	60.02	20.10	1.79	11.61	0.34	6.14
C. I. & L. R. R.—Average for 19 100,000-lb. consolidation locomotives	47.11	33.45	4.96	7.79	0.15	6.54
C. I. & L. R. R.—Average for 13 ten-wheel locomotives	28.16	53.97	2.38	2.46	0.19	12.84
C. I. & L. R. R.—Average for 26 150,000-lb. freight locomotives	39.03	47.73	1.75	4.11	.....	7.38
Seaboard Air Line—Average for 319 locomotives. All classes	89.9	.....	.....	10.1	.....	.....
Norfolk & Western	86.	3.4	0.1	1.7	0.3	8.5

TABLE II.—RECORD OF LOCOMOTIVE SERVICE FOR ONE ENGINE, ONE MONTH IN FREIGHT SERVICE. JANUARY 6 TO FEBRUARY 5, 1904.

TOTAL TIME OF TEST.	Hrs.	Min.	Hrs. 714	Min. 42	Per Cent.
MOTIVE POWER.					
1. Ash Pit (divided from average of a number of timings).					
(A) Waiting to get over pit	52	51			
(B) Cleaning fires	12	06			
(C) Coal and water	31	05			
2. Time in roundhouse for repairs	55	49			
3. Engine crew late	3	57			
4. Engineman not having engine ready	1	29			
5. Late leaving ash pit	2	08			
6. Repairs to machinery unfinished	1	56			
Total time in hands of Motive Power Dept.			161	21	22.6
TRANSPORTATION.					
(A) Delays due to Transportation Dept.					
1. Making up trains	10	00			
2. Switching	26	48			
3. Passing trains	133	14			
4. Trains ahead	40	37			
5. Orders	21	34			
6. Block	6	01			
7. Delays at R. R. crossings	1	40			
8. Yards blocked	10	24			
9. Section men	..	50			
10. Due to wrecks ahead	7	41			
11. Train crew late	..	32			
12. Waiting for orders in roundhouse	40	28			
13. Waiting on train at yards	2	01			
14. Coal and water on road	24	30			
15. Cleaning fire on road	7	33			
			333	53	46.8
(B) Delays due to Motive Power Dept.:					
1. Locomotives not steaming	1	23			
2. Hot gearings	1	48			
3. Drawbars	4	27			
4. Couplers	1	22			
5. Cleaning front end	..	30			
6. Due to air brakes	4	13			
			13	43	1.9
(C) Running time, not including taking coal and water on the road	205	39	205	39	28.7
Total time in hands of Transportation Dept.			553	15	77.4

BLE II.—*Continued.*

TOTAL TIME OF TEST.	Hrs.	Min.	Hrs.	Min.
			714	42
AT ENGINEHOUSE.				
1. Ash pit	96	02		
2. In house for repairs and care	59	53		
3. Detained at house waiting for crew	5	26		
4. Waiting at house for orders	40	28		
Total			201	49
AT YARDS.				
1. Making up trains	10	06		
2. Putting away trains	5	12		
3. Waiting on trains and orders	3	28		
4. Yards blocked	17	55		
5. Block	2	41		
6. Motive power delays	2	16		
7. Running time between house and yards	6	53		
Total			48	31
ON ROAD.				
1. Passing trains	128	36		
2. Trains ahead	37	44		
3. Switching	21	36		
4. Orders	20	07		
5. Block	3	20		
6. Miscellaneous	10	43		
7. Cleaning fire and taking coal and water on road	32	03		
8. Motive power delays	11	27		
9. Running time	198	46		
Total			464	22
Grand total			714	42

Total mileage on road	3129.	miles
Average running speed (miles per hour)	15.2	"
Average equivalent speed for transportation time	5.7	"
Average equivalent speed for total time of test	4.4	"
Mileage on fast freight	348.	"

DISTRIBUTION OF TIME WAITING FOR ORDERS IN ENGINEHOUSE.

	Per Cent. of Total Time.	Hrs.	Min.	No. of Times at House.
At Terminal A	40.	16	13	9
At Terminal B	34.6	14	00	7
At Terminal C	25.4	10	15	7

TABLE III.—RECORD OF LOCOMOTIVE SERVICE FOR ONE ENGINE, ONE MONTH IN FREIGHT SERVICE.—JANUARY 6 TO FEBRUARY 5, 1904.

SUMMARY.	Hrs.	Min.	Per Cent.
Charged to Motive Power—At Roundhouse:			
Waiting to get over ash pit	52	51	
Cleaning fires	12	06	
Coal and water	31	05	
	96	02	
In roundhouse for repairs	55	49	
Minor delays due to men	9	30	
Total time in hands of Motive Power Dept	161	21	22.6
TRANSPORTATION.			
Making up trains	10		
Switching	26	48	
Passing trains	132	14	
Trains ahead	40	37	
Orders	21	34	
Yards blocked	10	24	
Wrecks	7	41	
Waiting at roundhouse for orders	40	28	
Coal and water on road	24	30	
Cleaning fire on road	7	33	
Sundry small delays	12	04	
	333	53	46.8
Delays due to M. P.—Not steaming, hot boxes, drawbars, brakes	13	43	1.9
Running time	205	39	28.7
			100
Total time in hands of Transportation Department	553	21	77.4
Time at enginehouse	201	49	
Time at yards	48	31	
Time on road	464	22	
	714	42	
Running time	198	46	

THE PRESIDENT: The report is now open for discussion. We shall be pleased to hear from any of the members on this interesting subject.

MR. ANGUS SINCLAIR: I move that the report be received. (Motion seconded and carried.)

THE PRESIDENT: Mr. Clark, I see there are some figures from your road in the report. Can you add anything to the subject?

MR. F. H. CLARK (C. B. & Q. Ry.): I do not know anything about these figures, but I assume that they are fairly representative of our practice. We have recently gotten out some blanks on which the superintendents get daily statements of the time consumed in turning engines at terminals. The statement requires the coöperation of the yardmaster and roundhouse foreman, and shows the time of arrival of the engine at the yard, time of arrival at the roundhouse, the time when it was ready for service, the time ordered, the time out and some other information which enables us to determine very accurately whether we are getting a satisfactory movement of engines. It does not always enable us to keep the engines busy, because that depends on traffic, but it has enabled us in some cases to expedite the movement of engines in the house.

MR. F. F. GAINES (P. & R. R. R.): I have found where engines have been pooled that some system of keeping a record of the movement of the engine, not only from the time it starts out from a given point, but a record which shall include a complete cycle of the movement of the engine, has been beneficial. I found for my own protection in connection with the transportation department that after such a record had been established it enabled us to explain always, and quickly, why we could not furnish power, if we could not, and also called the attention of the transportation department frequently to the fact that they were holding out engines on the road and delaying them, and by getting together on the thing it resulted in materially increasing the engines available. (On motion the discussion was closed.)

THE PRESIDENT: The next paper is the report of the Committee on Shop Layouts, of which committee Mr. C. A. Seley is Chairman.

Mr. Seley presented the report as follows:

REPORT OF COMMITTEE ON SHOP LAYOUTS.

To the President and Members of the American Railway Master Mechanics' Association:

Your committee, to whom the question of Shop Layouts for Railroads having 350, 500, 750 and 1,000 locomotives was assigned, feels that the topic as presented is an impossible task for a number of reasons.

In no two cases are the conditions alike; available ground will not be of the same layout and topography; climatic conditions would vary the character of the building construction and the general character of the locomotive equipment to be repaired is not similar on all roads.

Few roads are so situated that one shop could take care of all their heavy repairs even if that were desirable, which we believe not. We do not at this time wish to take a stand for or against the large shop, meaning the extreme size possible. That question must be determined by the road or system for itself, viewing the question from the standpoint of road layout, organization, labor facilities, etc. The very large shop presents an opportunity for tying up the road by fire, strikes or accident that is not present when several smaller shops are used. On the other hand, it is hardly feasible to provide the smaller shops with all of the facilities and refinements now thought essential in the equipment of the large shop, and by these we mean not only the machine tools and handling appliances, but the multitude of small tools and appurtenances not generally reckoned or appreciated. Many roads lack in proper repair facilities at terminals and division points where the stitch in time saves many an engine failure. No matter how large and complete the main shop may be, the outlying points can advantageously and profitably use a moderate tool equipment for taking care of running and light accidental repairs, leaving heavy repairs and manufacturing to be done at the main shops. With such an equipment and organization, we believe that relatively small shops are undesirable, expensive and unprofitable, and that the larger, completely equipped main shops will handle the repairs in the most satisfactory manner.

The railroads represented in this Association have all kinds of shops, many of them capable of improvement, and in the last few years there has been a number of large shops built, no two on the same general plan, yet embodying more or less of the strictly modern lines of improvement in buildings, equipment and facilities. Railroad managements, owing perhaps to traditional conservatism, have not been quick to grasp the improvements in shop processes and equipment that are deemed essentials in other lines of business. It is true that railroads are not manufacturers, as a rule; but, if the repairs of locomotives and cars involve the same processes to a great extent as in their manufacture, either the manufacturers of railway equipment and machinery are unduly extravagant in providing roomy,

well-lighted buildings, traveling cranes and hoists, electric transmission of power and lighting, special tools of latest designs, all tending to labor-saving or putting the workmen on a better plane, or else the railroads are neglecting their opportunities and daily paying for it in the increased cost of their repairs.

Most of us, doubtless, have visited many shops where locomotives, cars and heavy machinery are built, and we could not help contrasting the methods of the successful manufacturers with those of the average railroad shop. If we analyze the matter and seek the reasons governing the situation on railroads, we find, first of all, that the average shop is planned and equipped for handling the average locomotive of say ten or fifteen years age and with machinery, much of it, of a greater age. During that period we have increased steam pressure 25 per cent, increased tractive power 50 per cent, increased total weight 75 per cent and tank capacities of 7,000 and 8,000 gallons are now common, an increase of nearly 100 per cent.

The demands of our managements for high speed and heavier tonnage to meet competition have brought about the development of machines for hauling trains that put the crack engines of a few years ago on the branch lines and on second-class trains or in the market for sale, to make way for heavier power. Wheels under the engines have been multiplied and so have cylinders. Rods are now so heavy that it takes a gang of men to handle them. Everything about the engines is on a larger scale, but how about the shops?

It is quite plain to our managements that it takes twice as long to water an engine with the 6-inch stand-pipes that were good enough in the old days and they see the necessity for enlarging on that line to cut down time.

Is it not equally important to supply facilities for handling the locomotive parts that have perhaps doubled in weight since the old shops were built? It used to be considered good enough to jack up an engine or, perhaps, to have a drop table for wheeling, and we are still doing too much of it, a practice that would be ridiculed by any live business man whose profits depended on modern methods of handling.

Now, whose fault is it that so many railroad shops are behind the times? It may be the fault of the management in not approving the recommendations of live motive power officers, who are awake to the situation and see their maintenance expense rising and are unable to check it on account of lack of facilities. The heavy modern engines do not stay out like the old timers and shoppings are more frequent, demanding greater shop facilities for a given number of engines than was necessary when engines were lighter, trains were shorter and time was longer. Some roads may think they are too poor to make these expenditures, and, of course, they should have our sympathy if this were true, but it is not.

Based on the principle that a manufacturing business will be most profitable when conducted with a plant, equipped with modern appliances, labor-saving devices for economical production, well organized and rationally directed; a railroad shop to be most efficient should be equally well equipped, organized and directed.

It is stated, however, in some quarters, that although the argument may be good, it has not been proven by the results obtained at the large modern shops, and that many old shops are yet more efficient than the new. It must be admitted that there is much of truth in this, but for reasons which, perhaps, can be explained and the difficulties to some extent can be overcome.

Some shops have been built that the money has been expended for ground and buildings and then these are filled with back-number machinery. In this case, aside from improved facilities for handling, no gain in the cost of the machine work is accomplished. A road with such a shop will need to make purchases of extra motive power in order to do business. When buying engines, if they would cut off one or two and expend their value in tools, the balance of the power could then be brought up so that the extra engines cut off would not be needed. It is not a question of how many engines a road has, but how many good, serviceable engines, and this depends on the facilities for repairing and keeping engines running. In this connection it is suggested that a system of cost keeping for manufactured work and various operations will shed much light on the comparative value of old and new machinery. The development in tool improvement and the use of high-speed steels has made large economies possible, the exact amount of which can only be determined by an accurate cost-keeping system, which can very profitably be carried out in the larger shops.

Another shop, equally well located and built, is equipped with a large line of modern tools, new from the makers. The shop is started and the management expects immediate results and they are not forthcoming. Why? Because the shop lacks that important equipment of the old shop in small tools, cutters, mills, jigs, formers, templates, bars, blocking, clamps and handy appliances that the old shop has been years in accumulating. The new shop will be handicapped for lack of these for some time, as they are an unappreciated asset in the business of the old shop.

Other well-equipped shops have been built at new points where the management deemed wise to locate, but almost invariably this has been the cause of long delay in getting together an organization to work the shop up to its capacity.

Railroad shop work can not be successfully performed by the floating element. A large proportion of the force must be permanent, settled in homes, convenient to schools and churches and other advantages and have something to live for beyond the empty honor of being an employee of the great North, East, South and West Railway.

No matter how well built and equipped the shop may be, its efficiency will be measured to a great extent by the class of men that can be obtained to work it. Unless the railroads are wise enough to see to it that they must, to a certain extent, bring the shops to the men, they will fail in getting the best material.

In order to get and hold the proper class of men, shop work should be fairly constant. Frequently the Motive Power Department is embarrassed by the difficulty in getting appropriations for maintaining force and organization at times when business is slack. When business is good, engines are worth from $25 to $50 per day, or perhaps more, and every day in the shop or out of service is that much loss. When business is dull and the full locomotive equipment is not needed, the engines needing repair could then be put through the shops and laid up ready for the return of business. By thus keeping engines up, a less number is needed, investment being devoted to maintenance, instead of multiplication. There is no doubt of the results of having a uniformly good standard of equipment, as against a lot of cripples, helped out with occasional new engines, often of new design, requiring time and considerable expense in getting patterns and repair parts.

The matter of recruiting for shop forces is one that is assuming considerable importance. We are not now making the all-around mechanics, which most of us were some years ago, equally at home on the machines, the bench or on the floor. The apprentice question is a vital one, deserving the attention of not only the motive power officers, but the higher officials, as well. As the older methods seem to be outgrown, new methods of recruiting must be tried, including, possibly, educational courses in connection with the shop work.

The difficulty of getting suitable men for foremen in smith shops and boiler shops is particularly noticeable. The spirit which at present dominates workmen is one apparently not elevating the more worthy or ambitious ones among them, but rather establishing a dead level of mediocrity from which it is difficult to select leading men for foremen and places of responsibility.

Some of this has been brought about by the increasing distance between the officers and the men, due to increase in the size of railroads, in many cases now amounting to many thousand miles and a vast number of men. Formerly a motive power officer knew almost every man on his pay-roll, and this personal contact, although not necessarily amounting to familiarity, nevertheless contributed to a spirit of *esprit de corps* that was invaluable in preserving organization, conserving good feeling and enabling prompt settlement of all questions.

Owing to the inability of the head of the motive power department of a great railroad to frequently visit outlying shops and terminals, this spirit is lost unless it is fostered by subordinate heads. The growth by

combinations, etc., of railway systems in the last few years has been so rapid that we have not had the time or opportunity of impressing this feeling on subordinates to the extent that it should be. Furthermore, in these expansions of railroads it is sometimes the case that the jurisdiction of subordinates is increased so as to cover too much territory, or in the case of foremen, they have too many men to handle to the best advantage. With the decreasing individual capacity of workmen, superintendence, supervision and instruction are more necessary than ever.

Suppose we have the big shop. It remains to get the best out of it, despite the possible drawbacks that have been named, and discover a policy, if possible, necessary for the success of these shops and the other big shops that are to come. As the big engines are handicapped by the small water cranes, small roundhouses and other small things, it is a possibility that the big shop is handled in a small way by a small man or, perhaps, by a big enough man, but tied down by small regulations and restrictions that do not permit him to do what could be done if he were more of a free agent. It is not well to give a small man a free hand, as he will make mistakes and is not equal to developing large things. The successful manufacturers have very competent men at the heads of their departments and they pay them salaries that railroad managements would deem extravagant for men having equal responsibility and the disbursement of, perhaps, greater amounts of pay-roll. The railroads must realize that for superior service, they must meet the salaries paid by the manufacturers. They have lost many a good man, who, while greatly desiring to remain in railway service, could not afford to do so in view of the inducements offered by the manufacturers. The railroads get more of what may be called professional service, not only in the motive power department — work of men who have to fit themselves by long training, by study and earnest effort — for less money than almost any other line of business.

For a successful shop manager, the man must not only have practical and technical knowledge and experience, but must have tact and a knowledge of men and affairs, dignity, yet with all a familiarity that will make the humblest employee feel that he has a friend, yet one that he must respect.

The complicated labor problems of to-day will not be less complex in the future. The proper labor equipment is so vital a factor in the successful operation of shops or business that the small man, or even the large man who has but limited opportunities, may fail in handling that feature in management.

The larger shops also present an opportunity for manufacturing on a very profitable basis the repair parts for storehouse stock and subsequent shipment to outside points.

The extent to which this may be done is almost entirely limited by

the machine facilities of the shops, such extra work demanding extra machinery. The output of the shops in engines should not be affected one way or the other by the manufacturing, which should be separately accounted for and properly credited. Many large shops do a great deal of work outside of the requirements for repairs of engines which they actually have on hand, and this, together with work for the other departments, such as bridge jobs, maintenance of pumping machinery, etc., form a very large portion of the output of many shops.

Manufacturing methods can also be extended to cover many of the regular shop operations, and by doing so this work can be reduced to a business basis, done on business methods.

Regarding the presentation of standard shop layouts, your committee has decided that it is best not to recommend any certain types, but to reproduce the articles on that subject contributed recently to the *American Engineer and Railroad Journal* by Mr. R. H. Soule, originally chairman of this committee. Mr. Soule was obliged to resign from the committee on account of the loss of health, and we regret losing the benefit of his assistance and advice in the preparation of this report.

The articles give the latest complete descriptions and analysis of the important railroad shops of this country and include data covering smith shops, car shops, stores, roundhouses, etc., but for the purposes of this report, only those portions relating to erecting machine and boiler shops are included, and these have been revised sufficiently to bring them up to date by including all data possible to obtain relative to the latest shops built.

C. A. SELEY, Chairman,
R. P. C. SANDERSON,
Committee.

CHICAGO, ILL., May 1, 1905.

NOTE.— Mr. H. D. Taylor does not agree with certain conclusions in the report; therefore, his name is omitted.

RAILWAY SHOPS.

The following is an abstract of a series of fifteen articles on the arrangement and proportions of railway shops, written by Mr. R. H. Soule, and published by the *American Engineer and Railroad Journal* in 1903 and 1904:

GENERAL CONSIDERATIONS.

Before taking up the different departments in detail it would be well to consider those more general questions which, in a problem of shop design, always precede the actual mapping out of the several buildings. The location is the first of these, and it naturally becomes fixed at what might be called, in a transportation sense, the center of gravity of the district or system to be served. This is always a terminal or division point, and often a junction point, as well. This consideration usually outweighs the question of labor and material supply, which otherwise would be the determining factor. It seldom has happened that shops were designed first, and a corresponding plot of land purchased subsequently; on the contrary, railway companies have usually anticipated the actual planning of new shops by acquiring available property adjacent to their right-of-way and otherwise favorably located. This has sometimes resulted in extremes, such as a nearly square tract of land, or, on the contrary, a long, narrow strip. The former condition is found at the Burnside (Ill.) plant of the Illinois Central Railroad, and the latter exists at the Horwich shops of the Lancashire & Yorkshire Railway of England. Either condition is a restraint on the free grouping of buildings and arrangement of track approaches; at both places very clever solutions have been found, however. The ratio of length to breadth in a plot of ground thus reserved for shop purposes should preferably fall between these extreme limits.

The shop site having been chosen and the land provided, the character and quantity of work to be done in the completed plant must be determined or assumed. This will usually crystallize out into a certain number of locomotives and cars, passenger and freight, to be maintained, or built, or both, per unit of time, usually per month. It is safer to proportion the shops on the basis of the greatest output likely to be required during any one month of the year, than it is to work on the basis of assuming the monthly output to be simply one-twelfth of the desired yearly output. The trend of organization, resulting from the general experience of railways, being toward merging the locomotive and car departments under one control, the typical railway central repair plant will comprise all of the several shops which are required in either connection. Separate locomotive and car repair plants may, of course, be justified where work of each kind is prosecuted on a large scale, or on account of special or local considerations. In the more general case of the combined shop, however, certain of the departments can be used jointly for both locomotive and car work; such, for instance, are the storehouse, the machine shop, the

smith shop, the foundry, the carpenter shop, and the paint shop. This list of joint shops emphasizes the fact that great economy can, in general, be accomplished by the concentration of the work of locomotive and car repairs into one group of buildings, as otherwise at least five of these six subdepartments (the foundry being possibly excepted) would have to be duplicated. When there is but one such group of buildings, yard service, whether by switching engine or laboring gang, can also be economized.

One-story buildings are always to be preferred if concentration does not have to be sacrificed. Day lighting and internal transportation are both easier to accomplish in one-story structures. The only exception to the general principle is in the case of those few departments where the work is light, such as the tin shop and the upholstery shop. The office and storehouse buildings may be, and generally are, of two-story construction, however. In this connection it must be acknowledged that artificial lighting, under present conditions, is so cheap and satisfactory that the shutting off of daylight does not reduce output as much as in the old days of oil lamps and torches.

Having determined the number of departments to be provided for, and the amount of work to be done, each must be considered separately and the essential dimensions fixed upon; but the grouping and relative arrangement of departments must be constantly borne in mind. Labor-saving devices are of first importance as features to be incorporated in the original design of a building; next in importance is the providing of such facilities of every sort as will guarantee that the labor which can not be saved but must be expended shall be used and applied under conditions of maximum efficiency and economy. The logic by which improvement investments are justified is simply a satisfactory demonstration that interest, depreciation and repairs will totalize less than the wages of unassisted labor would have amounted to in accomplishing the same result. A very satisfactory rule which is in use on one of our western lines is that any proposed improvement which will save labor amounting to ten per cent of its cost will be favorably considered. The credit of this company being on a three per cent basis, it is argued that such a transaction is virtually a seven per cent investment.

Each building having thus been worked out as a problem by itself, the grouping and layout can be considered. The evolution of recent years has tended toward bringing together under one roof such departments as are mutually dependent on one another, and have a continuous interchange of materials. The smith shop and the foundry are generally isolated on account of the smoke and dust which result from their operation. Buildings which must be separated, but which house departments which are dependent upon one another, should be kept as close together as possible. Modern practice tends toward restricting such inter-shop space to from 40 to 60 feet. While due regard must be given to the question of fire risk, it must not be allowed to exclusively dominate the situation, as in a recent case on an eastern trunk line where an insurance company which

had issued a blanket policy notified the railroad company that a proposed new erecting shop must not be within 100 feet of any adjacent building.

A prime requisite in planning railway shops is that the preliminary work shall be done by some one who has become familiar, by actual experience, with the operation of such shops. The architect has no legitimate place in this preliminary work, and his services, if needed at all, may be availed of when structural details and embellishments require attention. But the mechanical engineer and the civil engineer can cope with the bulk of the problems involved.

THE ERECTING SHOP.

Erecting shops may be broadly grouped as either longitudinal or transverse; longitudinal when the stall tracks run lengthwise of the shop, transverse when they run crosswise. In the longitudinal shop, three tracks run through the shop; in the transverse shop, any number of tracks (according to the length of the building) run across the shop. In the longitudinal shop the overhead traveling cranes for lifting engines must be two in number; in the transverse shop, but one such crane is required, although a second and lighter crane on a lower level is often provided. In the longitudinal shop, engines are brought in on the middle track, are generally stripped and unwheeled on that track, and are then placed on one of the side tracks for repairs. In a transverse shop, which is provided with an adjacent transfer table, engines may be run in on any track. If there is no transfer table, engines are brought in on some one designated track, and lifted (over intermediate engines, if necessary) to some other track; they may be stripped and unwheeled either on the track on which they are brought in, or on the track on which they are subsequently placed; practice varies in this respect. Fig. 1 is a typical cross-section of a longitudinal shop; Fig. 2 of a transverse shop, with crane equipment on one level; Fig. 3 of a transverse shop, with crane equipment on two levels; Fig. 4 is that particular modification of the Fig. 2 type which is found in the case of the Baldwin Locomotive Works at Philadelphia. Tables 1, 2 and 3 give the essential dimensions and data for several shops of each type.

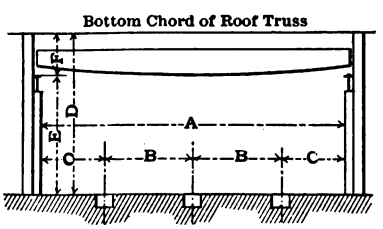


FIG. 1. Cross-section of longitudinal erecting shop.

First considering longitudinal shops in connection with Fig. 1 and Table 1, an examination of column B discloses a marked tendency to

| | | |

TABLE 3.—DATA FOR TRANSVERSE ERECTING SHOPS WITH CRANES ON TWO LEVELS. (See Fig. 3.)

WITHOUT TRANSFER TABLE.

PLACE.	R. R. or Loco. Co.	Year built.	Approx. Cross-section Dimensions.						Approx. Length of Shop.	Available Stall Tracks.		Cranes. s. t.—sing. trolley. d. t.—d'ble trolley.	Machine Shop Location.
			Horizontal.			Vertical.							
			A	B	D	E	F	G		No.	Spread C to C		
			Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft.		Ft Ins.		
Dunkirk, N. Y.	Am. Loco. Co.	1899	63—0	40—0	50—1	27—8	10—10	11—7	255	17	14—0	1 d.t., 100-ton 1 s.t., 10-ton	One side, same bldg.
Richmond, Va.	Am. Loco. Co.	1902	66—5	No pits.	52—5	30—11	10—0	11—6	303	17	16—0	1 d.t., 120-ton 1 d.t., 30-ton	One end, sep. bldg.
Paterson, N. J.	Rogers Loco. Works.	1902	59—11	38—0	50—0	27—10	12—2	10—0	261	16	15—5	1 d.t., 120-ton 1 d.t., 25-ton	One end, sep. bldg.
Reading, Pa.	P & R	1902	66—8	45—0	46—6	27—11	10—1	8—6	740 740	70	20—0	1 d.t., 120-ton 1 d.t., 35-ton	One side, same bldg.
Collinwood, Ohio.	L. S. & M. S.	1902	64—2	38—0	47—0	26—3	12—1	8—8	530	23	22—0	1 d.t., 100-ton 1 s.t., 10-ton	One side, same bldg
McKees Rocks, Pa.	P. & L. E	1903	60—2	33—0	49—1	26—3	12—1	10—9	528	20	24—0	1 d.t., 100-ton 1 s.t., 10-ton	One side, same bldg.

TABLE 2.—DATA FOR TRANSVERSE ERECTING SHOPS WITH CRANES ON ONE LEVEL. (See Fig. 2.)

WITH TRANSFER TABLE.

PLACE.	R. R. or Loco. Co	Year built.	Approx. Cross-section Dimensions.					Approx Length of Shop.	Available Stall Tracks.		Cranes, s. t. = sing. trolley. d. t. = d'ble trolley.	Machine Shop Location.
			Horizontal.		Vertical.							
			A	B	D	E	F		No.	Spread C to C.		
			Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft.		Ft. Ins.		
Bloomington, Ill.	C. & A.	1883	58–8	34–0	26–3	21–6	4–9	404	16	22–0	2 d.t., 50-ton	One side, same bldg.
Schenectady, N. Y.	Am. Loco. Co.	1892	61–0	34–0	34–0	27–6	6–6	317	17	17–0	2 d.t., 40-ton	One side, sep. bldg.
Burnside, Ill.	I. C.	1892	74–6	67–6	31–6	21–0	10–6	550	24	22–0	1 d.t., 100-ton	One side, same bldg.
Depew, N. Y.	N. Y. C.	1893	65–0	36–0	34–0	22–6	11–6	500 500	46	20–0	2 d.t., 60-ton	One end, sep. bldg.
Fond du Lac, Wis.	W. C.	1900	57–8	32–9	27–2	20–2	7–0	329	15	22–0	2 d.t., 30-ton	One side, same bldg.
Oelwein, Iowa.	C. G. W.	1900	57–4	35–0	33–6	26–4	7–2	390	13	25–0	1 s.t., 15-ton 1 d.t., 65-ton	One side, same bldg.
Brainerd, Minn.	N. P.	1900	(e. s. & m.	s. in three bays 130'		over all)		570	25	22–0	Crane in middle bay only	One side, same bldg.
Hannibal, Mo.	H. & St. J.	1901	61–3	45–0	34–0	26–5	7–7	227	10	22–6	1 s.t., 15-ton- 1 d.t., 70-ton	One side, same bldg.
Baring Cross, Ark.	M. P.	1902	68–0		35–2	26–3	8–11	330	15	22–0	1 s.t., 15-ton 1 d.t., 70-ton	One side, same bldg.
Oak Grove, Pa.	N. Y. C.	1903	68–6	40–0	40–0	28–0	12–0	425	19	22–0	1 s.t., 30-ton 1 d.t., 75-ton	One side, same bldg.

WITHOUT TRANSFER TABLE.

Philadelphia, Pa.	B. Loco. Works.	1891	See Fig. 4. (No. Pits.)					335	19	16–0	2 d.t., 100-ton	One side, sep. bldg.

NOTE.—The heavy cranes at Oelwein, Hannibal, Baring Cross and Oak Grove are "dummies," i. e., can only lift by their own mechanism; the trolleys are moved by hand, and the bridge by the light crane.

TABLE 3.—DATA FOR TRANSVERSE ERECTING SHOPS WITH CRANES ON TWO LEVELS. (See Fig. 3.)

WITHOUT TRANSFER TABLE.

PLACE.	R. R. or Loco. Co.	Year built.	Approx. Cross-section Dimensions.						Approx. Length of Shop.	Available Stall Tracks.		Cranes. s. t.—sing. trolley. d. t.—d'ble trolley.	Machine Shop Location.
			Horizontal.			Vertical.							
			A	B	D	E	F	G		No.	Spread C to C		
			Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft. Ins.	Ft.		Ft Ins.		
Dunkirk, N. Y.	Am. Loco. Co	1899	63—0	40—0	50—1	27—8	10—10	11—7	255	17	14—0	1 d.t., 100-ton 1 s.t., 10-ton	One side, same bldg.
Richmond, Va.	Am. Loco. Co	1902	66—5	No pits.	52—5	30—11	10—0	11—6	303	17	16—0	1 d.t., 120-ton 1 d.t., 30-ton	One end, sep. bldg.
Paterson, N. J.	Rogers Loco. Works.	1902	59—11	38—0	50—0	27—10	12—2	10—0	261	16	15—5	1 d.t., 120-ton 1 d.t., 25-ton	One end, sep. bldg.
Reading, Pa.	P & R	1902	66—8	45—0	46—6	27—11	10—1	8—6	740 740	70	20—0	1 d.t., 120-ton 1 d.t., 35-ton	One side, same bldg.
Collinwood, Ohio.	L. S. & M. S.	1902	64—2	38—0	47—0	26—3	12—1	8—8	530	23	22—0	1 d.t., 100-ton 1 s.t., 10-ton	One side, same bldg
McKees Rocks, Pa.	P. & L. E	1903	60—2	33—0	49—1	26—3	12—1	10—9	528	20	24—0	1 d.t., 100-ton 1 s.t., 10-ton	One side, same bldg.

and Tables 2 and 3, it is evident that a width of 65 feet between crane runway posts (dimension A) is sufficient for slinging and handling engines by the overhead cranes even in those transverse shops which have no transfer table (Fig. 3 and Table 3) and are entirely dependent on overhead cranes. Where this width is made more than 65 feet, it is generally done with the object that the overhead cranes may serve a fringe of heavy tools which are placed along one edge of the erecting shop bay. In the five transverse construction shops, the spread of stall tracks ranges from 14 feet to 17 feet, which makes it hard to justify a spread greater than 20 feet in the transverse repair shop, especially if strippings are stored elsewhere than between stalls on the floor level. It is evident that the height (dimension D) of a transverse shop equipped with cranes may vary between the extremes of 35 feet and 50 feet, but if we assume that it is desirable to have at least enough head room to lift a boiler over an engine, 40 feet becomes the minimum, and three heights may be taken as representative of different combinations, as follows:

TABLE 4.—HEIGHTS OF TRANSVERSE ERECTING SHOPS.

Combination 1.—One level (Fig. 2); one crane, say 30 tons, to lift boilers over engines; one dummy crane, say 75 tons, to unwheel engines, but not to lift engines one over another (as at Oak Grove)
Transfer table required. Height.....40 ft.

Combination 2.—One level (Fig. 2); one heavy crane, say 120 tons, to lift engines one over another (as at the Baldwin Locomotive Works).
No transfer table required. Height.....45 ft

Combination 3.—Two levels (Fig. 3); one light crane, say 10 tons; one heavy crane, say 120 tons, to lift engines one over another (as at all shops in Table 3).
Height .....50 ft.

A comparison of the dimensions of the typical longitudinal erecting shop and the three suggested alternative arrangements of the transverse erecting shop is given in Table 5.

TABLE 5.—DIMENSIONS FOR ERECTING SHOPS PER ENGINE

Item.	Longitudinal.	Transverse.		
		Combination 1.	Combination 2.	Combination 3.
Floor-space dimensions (in feet)	45 x 38	65 x 20	65 x 20	65 x 20
Floor-space area (in square feet)	1,710	1,300	1,300	1,300
Height to roof truss (in feet) ...	40	40	45	50
Volume (in cubic feet).....	68,400	52,000	58,500	65,000

TABLE 6.—LONGITUDINAL AND TRANSVERSE ERECTING SHOPS COMPARED.

Item.	Longitudinal.	Transverse.
Layout	Can be placed parallel to general line of tracks and entered by direct track connection	If placed parallel to general line of tracks, must be entered by turntable. If entered by direct track connection, must be placed crosswise to general line of tracks.
Structural	Width of bays (distance between roof trusses) can be determined by conditions of economy alone	Width of bays must be same as spread of stall tracks, whether economical or not.
Compactness (say for shop with 20 engines)	450 feet long by 76 feet wide. Less compact	400 feet long by 65 feet wide. More compact.
Access from other shops	Must be across the pits	Not necessary to cross the pits.
Lighting (day and night)	More difficult	Easier and better.
Lifting engines	Engines have to be lifted only high enough to clear driving wheels; less time consumed	Engines have to be lifted high enough to clear adjacent engines; more time consumed.
Moving engines horizontally	Less distance under average conditions.	More distance under average conditions.
Dropping engines onto their wheels	More use of cranes and less manual labor (in handling wheels)	Less use of cranes and more manual labor (in handling wheels).
Flexibility in general use of shop	Greater	Less.

At this point it may be noted that in longitudinal shops the track pits are usually continuous, being bridged across between engines, where necessary; in transverse shops, the length of pits (dimension B in Tables 2 and 3) varies greatly, but 40 feet may be taken as a fair average. The depth of pits does not appear in the tables, but has been found to average 2 feet 6 inches. The width of pit for track 4 feet 8½ inches comes to about 4 feet 0 inches.

Examining Table 5, it is found that the transverse shop requires less floor space than the longitudinal shop by about 24 per cent, and less volume by 38, 14 and 5 per cent for the three types respectively. The relative costs would be modified, however, by the crane equipment, and in general, the crane runways of transverse shop without transfer tables have to sustain twice the load at any given point that the runways of longitudinal shops do, because the maximum load must be carried by one crane, instead of by two as in a longitudinal shop. The use of dummy cranes (see footnote, Table 2), however, imposes their maximum load on crane runway posts only, while the intermediate girders have to sustain the load of the adjacent lighter crane only. The one safe basis for comparing costs is actual estimate.

The relative merits of the l i e shop and transverse erecting shop without transfer in t, Table 6.

For very large installati a the

TABLE 7.—OUTPUT OF ERECTING SHOPS OF THE SEVERAL TYPES.

Place.	Railroad or Locomotive Company.	Year Built.	Available No. of Stalls.	Machine Shop. Floor Space (Sq. Ft.). Total.	Machine Shop. Floor Space (Sq. Ft.). Per Stall.	No. Locomotives turned out per month. Ten-hour Basis. Total.	Ten-hour Basis. Per Stall.	With Overtime. Total.	With Overtime. Per Stall.	Nature of Work for which Machine Shop tool equipment is provided.
LONGITUDINAL REPAIR SHOPS.										
Altoona, Pa., No 1	Pennsylvania.	1875	18	120,350	3,343	115	3.19	140	3.88	Loco. repairs.
Altoona, Pa., No. 2	Pennsylvania.	1883	18							
Roanoke, Va	N. & W.	1883	e. s. 10 r. h. 14	25,900	1,079	50	2.08	57	2.33	Loco. and car repairs.
Burlington, Iowa	C. B. & Q.	1883	12	19,215	1,601	16	1.33	.....	.....	Loco. and car repairs.
Baltimore, Md.	B. & O	1896	30	82,756	2,759	35	1.17	.....	.....	Loco. and car repairs.
Concord, N. H.	B. & M.	1897	14	18,300	1,307	15	1.07	.....	.....	Loco. and car repairs.
Elizabethport, N. J.	C. R. R. of N. J	1902	18	31,500	1,750	25	1.39	.....	.....	Loco. and car repairs.
Omaha, Neb.	U. P	1902	18	42,700	2,372	22	1.22	.....	.....	Loco. and car repairs.
Topeka, Kan	A. T. & S. F.	1903	22	58,125	2,642	.....	.....	.....	.....	Loco. and car repairs.
Jackson, Mich	M. C	1903	l. e. s. 14 t. e. s. 7	39,740	1,806	.....	.....	.....	.....	Loco. repairs.
Montreal, Can	C. P.	1903	36	94,500	2,625	50	1.39	.....	.....	Loco. and car repairs.
Portsmouth, Ohio.	N. & W.	1903	6	11,232	1,872	.....	.....	.....	.....	Loco. repairs.
Moline, Ill.	C. R. I. & P.	1903	*50	72,288	1,446	.....	.....	.....	.....	Loco. repairs.
TRANSVERSE REPAIR SHOPS.										
Bloomington, Ill.	C. & A.	.....	16	23,390	1,462	27	1.69	.....	.....	Loco. and car repairs.
Burnside, Ill.	I. C	1892	24	42,900	1,787	27	1.13	.....	.....	Loco. and car repairs.
Depew, N. Y	N. Y. C.	1893	46	30,540	664	53	1.15	.....	.....	Loco. repairs.
Brainerd, Minn	N. P	1900	25	47,465	1,898	28	1.12	.....	.....	Loco. and car repairs.
Oelwein, Iowa	C. G. W	1900	13	24,180	1,860	18	1.38	.....	.....	Loco. and car repairs.
Fond du Lac, Wis.	W. C.	1900	15	21,142	1,409	.....	.....	.....	.....	Loco. and car repairs.
Hannibal, Mo	H. & St. J	1901	10	19,272	1,927	12	1.20	.....	.....	Loco. and car repairs.
Collinwood, Ohio.	L. S. & M. S.	1902	23	45,580	1,982	35	1.52	.....	.....	Loco. and car repairs.
Reading, Pa.	P. & R	1902	70	44,400	634	69	.99	.....	.....	Loco. repairs.
Baring Cross, Ark.	M. P	1902	15	32,010	2,134	.....	.....	.....	.....	Loco. and car repairs.
McKees Rocks, Pa.	P. & L. E	1903	20	52,272	2,614	.....	.....	.....	.....	Loco. and car repairs.
Oak Grove, Pa.	N. Y. C.	1903	19	21,250	1,118	18	.94	.....	.....	Loco and car repairs.
LONGITUDINAL CONSTRUCTION SHOPS.										
Altoona, Pa. (Juniata).	Pennsylvania.	1891	8	51,375	6,422	8.5	1.06	10	1.25	Loco. construction.
TRANSVERSE CONSTRUCTION SHOPS.										
Philadelphia, Pa	Baldwin Locomotive Works	1891	60	416,074	6,935	.....	.....	128	2.13	Loco. construction.
Schenectady, N. Y	American Locomotive Co	1892	17	116,555	6,856	40	2.35	50	2.94	Loco. construction.
Dunkirk, N. Y.	American Locomotive Co	1899	17	115,579	6,799	30	1.77	40	2.35	Loco. construction.
Richmond, Va.	American Locomotive Co	1902	17	56,097	3,300	18	1.06	25	1.47	Loco. construction.
Paterson, N. J.	Rogers Locomotive Works	1902	16	93,849	5,865	20	1.25	.....	.....	Loco. construction.

NOTES.—e. s., erecting shop; r. h., roundhouse; l. e. s., longitudinal erecting shop; t. e. s., transverse erecting shop.

* Longitudinal erecting shop with longitudinal and diagonal pits.

longitudinal erecting shop and the transverse erecting shop without transfer table, but there are many cases of small installations where a transfer table is required for handling passenger cars, and may also be conveniently used for handling engines in and out of an erecting shop. Wherever the transfer table is used, however, to give access to a shop, efficient lighting and heating are impaired, bench or storage room is sacrificed inside the building, and yard room outside.

The output of several erecting shops of both the longitudinal and transverse types is shown by Table 7, which also shows the machine shop floor area and the variety of work undertaken in the machine shop, as these are perhaps the two most important influences which affect the output. The number of locomotives turned out per stall per month on the ten-hour basis is the safest criterion for making comparisons, as overtime is an indefinite quantity.

Attention is called to the fine results shown for the longitudinal shops of the Pennsylvania Railroad at Altoona, and the Norfolk & Western at Roanoke, on repair work, and for the Schenectady works of the American Locomotive Company on construction work. It should also be noted that these are all comparatively old, though modern shops, and have had the great advantage of perfecting the details of their equipment and organization, whereas the many shops built since 1900 are all still either incompletely equipped or organized. Several of the railway shops listed in Table 7 are turning out new, as well as repaired, locomotives, but in each such case the output shown in the table is that which would be, or actually has been, accomplished were no new engines being built.

Among the repair shops, Altoona shows the largest machine shop floor space per erecting shop stall. The case of Roanoke is unique, as showing, apparently, a small machine shop floor space per engine. The erecting shop stands ten engines, and on that basis the machine shop floor space is 2,590 square feet per engine, a comparatively high figure; but an adjacent roundhouse, abandoned for road work, is used as an annex to the erecting shop and stands fourteen engines, which are unwheeled and wheeled in the erecting shop and hauled back and forth between erecting shop and roundhouse on special trucks. The total number of engines under erecting shop treatment being twenty-four, the machine shop floor space is reduced to 1,079 square feet per stall, which suggests that good crane facilities perhaps have quite as much influence on output as does liberal machine shop floor space. It is interesting to note that the principal construction shops follow a much more uniform practice in providing machine shop floor area per erecting shop stall than do the railway repair shops.

In considering these output figures it should be borne in mind that the cost of the work done has not been touched upon, and that it does not necessarily follow that where the output per stall is largest the cost per unit of work done is the least.

The storage of engine strippings in repair shops is not reduced to any uniform practice, and is worthy of more consideration when new shops

are being designed. The use of special pits, between tracks, for this purpose, has been tried and abandoned in certain cases, but is nevertheless a feature in some new erecting shops now under construction. The indications are that a final solution of this problem will embody some proper provision of racks and bins on the floor level and closely adjacent to the engines under repairs, but not between stall tracks.

Although the longitudinal erecting shop has been credited, in the foregoing, with great flexibility of operation, yet its design is quite stereotyped; on the other hand, the transverse erecting shop, in conjunction with adjacent crane served bays, offers opportunity for a great number of variations and combinations, and it is entirely possible that the transverse type may find favor in some of the large problems of the future.

THE MACHINE SHOP.

The machine shop floor area per erecting shop stall, for a large number of shops, both repair and construction, has been given in Table 7, an analysis of which discloses the fact that although there are wide limits of practice, there is nevertheless evidence that a liberal provision of machine shop floor space very favorably affects erecting shop output. The exact amount of machine shop floor space which it is best to provide for a given installation is an economic problem which involves consideration of the questions of interest on capital, land values, etc. The design of a machine shop not being limited to a few types, but in fact admitting of great variations, it is not practicable to give one or more typical cross-sections, as was done in the case of the erecting shop, but certain essential features may be considered and discussed.

Good practice requires the use of firm floors. Where laid on earth a stratum of concrete should be interposed. This need not necessarily be the usual cement, sand and broken stone mixture, but rather some cheaper substitute which may make use of locomotive front end cinders flushed with tar or asphaltum, the whole covered by a layer of planking and a thinner top dressing which may be easily renewed in spots. Such a floor construction makes foundations quite unnecessary, except for a few of the heavier tools; these and other tools which have individual electric drives are relieved from belt pull tending to lift them from or shift them on their foundations, while lighter shaft-driven tools may be fastened down with lag screws or hook bolts. In a two-story structure the upper floor should be of heavy planking, with top dressing as before.

The loss of time resulting from the use of two-story structures for machine shop purposes, though indeterminate, is nevertheless actual and inevitable, and that form of construction should not be resorted to unless for the reason that land is obtainable only at a prohibitive price. In addition to the loss of time resulting from the transportation of men and materials, there is a loss of floor space, repeated on each floor, where stairways and elevators are provided, and the loss which comes from the impaired lighting of the lower story. Besides this, it is often necessary to

introduce columns to support the second floor, and these are an obstruction and interfere with the grouping of tools and the movement of men and materials on the first floor.

In the machine shop department of the average locomotive repair shop it is seldom the case that tools occupying more than one-third of the total floor space can be served to best advantage by an overhead traveling crane, and it so happens that these are the tools which are best adapted to the individual electric drive and do not require overhead shafting. If driving wheels are stored inside the building, it may be necessary to increase the amount of floor space covered. The balance of the tools can be better served by local and individual cranes and hoists, which also permit of the placing of shafting and motors overhead. Every machine shop should be so designed that all shafting may be hung either from the roof trusses, from walls, or from structural columns, as floor stands, for shafting supports are very much in the way and occupy space which is valuable for other and more legitimate purposes. The walking crane is not as well known in this country as in England, but as modernized and adapted to be electrically driven is a very satisfactory appliance. It takes up a minimum of floor space and head room, has a deck on which material may be laid, does not require highly skilled labor to operate, and leaves the operator free to assist in adjusting slings, etc., which can not be done by traveling crane operators.

The traveling crane equipment and the head room of several machine shops are given in Table 8. A capacity of ten tons appears to be sufficient for the traveling crane. Its heaviest load would probably be a pair of cylinders bolted together, which, in the case of some compound engines, weigh upward of eight tons. When the head-room figures are examined in connection with the designs from which they were taken it is found that certain apparently excessive dimensions are accounted for by structural considerations. Eliminating these, it would appear that in one-story machine shop structures 25 feet is sufficient head room in a crane bay (of moderate width), while 20 feet is liberal in a bay where cranes are not used. When these limits are exceeded, it is for structural reasons (as stated before) or, in the case of very broad shops, to secure better lighting. Where there is a second story in a bay where cranes are not used, the head rooms on the first and second floors might be taken as approximating 18 and 15 feet respectively.

The structural designs and specifications of a building to be used as a machine shop should require that the members, whether roof trusses or floor girders, from which shafting, hoists, etc., are to be hung, should be built truly horizontal, without camber, and should expose below broad flat surfaces with flanges, over the edges of which hook bolts may be attached. This construction permits the attachment of supports for shafting, hoists, etc., without drilling holes in metallic members, and facilitates slight changes of location, which often become necessary.

The selection of tools for the machine shop is a matter of critical

TABLE 8.—TRAVELING CRANE EQUIPMENT AND HEAD ROOM IN SEVERAL TYPICAL MACHINE SHOPS.

Place.	Railroad.	Year Built.	Traveling Crane Equipment.	Head Room (Approximate).		
				Where Cranes Are Used.	Where Cranes are Not Used.	
				Ft. Ins.	1st Floor. Ft. Ins.	2d Floor. Ft. Ins.
Depew, N. Y.	New York Central	1893			22—0	
Concord, N. H.	Boston & Maine	1897			18—0	
Chicago, Ill. (Annex)	Chicago & North-Western	1900			18—0	13—0
Belwein, Iowa	Chicago Great Western	1900	1 15-ton	33—6	17—9	14—7
Fond du Lac, Wis.	Wisconsin Central	1900	2 5-ton	22—9	22—9	
Hannibal, Mo	Hannibal & St. Joseph	1901			16—4	16—4
Dubois, Pa.	Buffalo, Rochester & Pittsburg	1901			20—0	
Elizabethport, N. J.	Central Railroad of New Jersey	1902	1 10-ton 1 5-ton	30—9	20—3	
Reading, Pa.	Philadelphia & Reading	1902	2 10-ton	33—5	Cranes throughout.	
Baring Cross, Ark.	Missouri Pacific	1902			21—0	
Omaha, Neb.	Union Pacific	1902	2 10-ton	40—0	19—0	17—6
Pocatello, Idaho	Oregon Short Line	1902	1 10-ton	39—0	19—0	17—6
Jackson, Mich	Michigan Central	1903	1 7½-ton		18—6	
Topeka, Kan.	Atchison, Topeka & Santa Fe	1903	2 5-ton	20—0	15—0	12—0
Oak Grove, Pa.	New York Central	1903			18—0	
Montreal, Can.	Canadian Pacific	1903	2 10-ton	32—9	19—0	17—9
McKees Rocks, Pa	Pittsburg & Lake Erie	1903		25—9	Cranes throughout.	
Moline, Ill.	Chicago, Rock Island & Pacific	1903	2 3½-ton 1 10-ton	33—4	19—0	

importance, especially under existing conditions, when tools are being redesigned and their output modified by the use of new cutting steels and the electric drive. The safest way in the case of a new and large plant would be to organize a special commission to deal with the question and prepare the list. Two or three men who had actual charge in large shops and say two representatives of the tool manufacturers could, by comparing the tool lists of existing plants, jointly determine the requirements of the plant under consideration. It is not simply a question of the design and specification of each individual tool, but also the question of how many tools of each kind are needed in order that work on the several parts of the locomotive may progress at such a rate that the finished work will be ready a little in advance of the schedule time when it may be required.

The location and grouping of tools may be governed by a few general principles. The heavier tools (say those requiring five horse-power or over to drive) should be located under a traveling crane. Tools working exclusively on castings should be placed near the point at which castings are received into the shop. Those working exclusively on forgings should be placed near the receiving point for forgings. Different tools engaged on the various processes of producing one finished article should be grouped together. Sufficient floor space adjacent to each tool should be reserved for the storage of a reasonable quantity of raw material and finished product. Passageways for the movement of men and material must be reserved.

In applying these principles to a given plant, it will at once be found that their claims are often conflicting, and that a judicious compromise must be effected. Such necessary compromise should never fail, however, to provide direct passageways for the movement of material along those lines on which the work naturally progresses. In a locomotive shop, whether for construction or repairs, a great advantage is gained if driving wheels can be handled entirely by the same cranes that cover the erecting stalls; otherwise the wheels must be rolled from one crane bay to another, which seems easy, but is actually a laborious operation, and open to many inconveniences and objections, owing to the excess of counterbalance. Custom has placed the heavier tools on that side of the machine shop nearest to the erecting shop; this practice has undoubtedly been copied from locomotive construction shops, but can hardly be justified for repair shops, where the aggregate movement of high-priced labor between locomotives and light tools greatly exceeds the aggregate movement between locomotives and the heavy tools, this latter being done, moreover, by cheap labor.

Although a layout plan showing tool locations should always be made in advance, yet it should never be regarded as final, and the person having charge of the actual placing of the tools in the shop should be empowered to make considerable variations in the location of individual tools, provided the general scheme of grouping is adhered to. After all the tools have been actually located, a final layout plan may be made for purposes

of record. In this connection it should be stated that in general it is cheaper in the end to duplicate lighter tools, say up to a value of $500 each, rather than to be compelled to transport material long distances from some other tool by which it has been partly finished. The duplication of such light tools in different places is simply a recognition of one of the principles mentioned above.

The best method of driving tools is undoubtedly the electric drive applied individually to the heavier tools, to isolated tools, to those lighter tools which require the use of variable speed, and applied collectively to groups of such lighter tools as may be economically run at approximately constant speeds. Under present conditions, direct current best meets all the conditions, but when the induction motor can be made to give a variable speed, then the alternating current will undoubtedly be the primary current, which may be transformed into direct current for the few remaining applications where the direct current will give better results. Every electrically driven shop should have motor speed control attachments to certain motors, but it is not possible to here discuss the relative merits of rheostatic control, field control, or multivoltage control, which may be combined and modified in various ways. Data on the power required to drive individual tools have been accumulating so rapidly since the electric drive was introduced that the rating of tools has become comparatively easy; similarly, enough completed plants have been in operation under close observation to enable the designer of new plants to assume a load factor for group drives which will insure an abundance of power at the tools on the one hand and on the other will keep the size of the motor down to an economical limit.

A well appointed tool room should be a feature of every machine shop, but its scope and design admit of such wide variation that no standard proportions can be established. The principal requisites are that its location should be central and its equipment complete and liberal.

THE BOILER SHOP AND THE SMITH SHOP.

As in the case of the machine shop, the boiler shop does not admit of classification into a few types; a great variety of cross sections may be used, and many combinations of length and width; the requisites are floor space in proper proportion to the number of locomotives to be handled, proper provision of crane facilities, and sufficient tool equipment. Before the introduction of the overhead traveling crane, boilers were moved between erecting shop and boiler shop on trucks by transfer table, and tracks extending into the boiler shop were a necessity; under present conditions no boiler shop need have more than a single track extending into it. In general, the boiler shop floor should be of wood, but about flange fires and forges should preferably be of earth, as a wood floor in those places will burn out very rapidly.

In any locomotive shop it would be an advantage to have the erecting

shop and the boiler shop so located and related that they could have joint crane service; this can not always be accomplished, however, and it is believed that there is not a single locomotive construction shop so arranged. Among locomotive repair shops several cases are found, for instance: Roanoke, Va. (N. & W.); Concord, N. H. (B. & M.); Dubois, Pa. (B. R. & P.); Elizabethport, N. J. (C. R. R. of N. J.); Reading, Pa. (P. & R.); Topeka, Kan. (A. T. & S. F.), and Montreal, Can. (C. P.). Although joint crane service between erecting and boiler shops is believed to be very desirable and economical, it is only fair to mention some other very successful shops where the two departments are separate and independent, for instance: Burlington, Iowa (C. B. & Q.); Chicago, Ill. (C. & N.-W.); St. Paul, Minn. (C. St. P. M. & O.); Omaha, Neb. (U. P.); Burnside, Ill. (I. C.); Collinwood, Ohio (L. S.); Depew, N. Y. (N. Y. C.); McKees Rocks, Pa. (P. & L. E.), and Altoona, Pa. (P. R. R.). Compromise arrangements may be found at Jackson, Mich. (M. C.), and Columbus, Ohio (Pa. Lines); at both places the erecting shop cranes cover a portion of the boiler shop only.

In most locomotive repair plants one building serves for both boiler shop and tank shop, but separate tank shops are found at Chicago, Ill. (C. & N.-W.); Altoona, Pa. (P. R. R.), and Baltimore, Md. (B. & O.); those at Altoona and Baltimore are longitudinal, while that at Chicago is transverse; in some respects a transverse shop is more convenient for tank repairs, as tenders do not receive as uniform treatment as locomotives do, and in many cases do not require handling by cranes at all, so that it is an advantage to be able to let them stand on the track on which they were originally placed, which could not be done in a longitudinal shop; the penalty for the transverse shop is either a transfer table or a system of fantail tracks for approach.

In a boiler shop traveling crane service may be provided to good advantage over a much larger proportion of the floor space than in the machine shop; this is due to the fact that both the work and the tools are so much heavier in the boiler shop, and that the tools practically all have individual motor drives. In a boiler and tank shop the traveling cranes will be needed for moving and turning boilers and tanks, but nearly every individual tool will have to be provided with its own individual crane or hoist, or swing crane and hoist combined, these local cranes being in general hand-operated. If boiler plates are stored outside the building, it will pay to install a hand or power yard crane over them, even in moderate-sized plants.

The headroom in the boiler shop is often influenced by structural considerations, as always, for instance, where the boiler shop is an extension of the erecting shop and having joint crane service with it; but where there are no such limitations it may be assumed that the figures may be as in Table 9, the conditions being normal and the width of crane bays mod-

TABLE 9.—HEAD ROOM FOR BOILER SHOPS.

Particular.	From floor to top of rail. Ft. In.	From floor to lower chord of roof truss. Ft. In.
Where heavy traveling cranes (say 35 tons) are used	28—0	35—0
Where light traveling cranes (say 5 tons) are used	19—0	24—0
In wings where many swing cranes are used	.....	22—0
In wings without cranes	.....	20—0

erate; the exact vertical distance between top of crane runway rail and lower chord of roof truss should be fixed only after the exact type and make of crane for each particular location has been chosen.

The capacities of boiler shop cranes under present conditions may be assumed to be as in Table 10.

TABLE 10.—CAPACITIES OF BOILER-SHOP CRANES.

For What Purpose Used.	Capacity.
General floor crane	35 tons.
Riveting tower	25 "
Side bays	5 "
Local cranes over tools, from 1 up to	2 "

A list of tools for the boiler shop can be made up only for each concrete case; the very first thing to be known is whether a riveting and flanging plant is to be included, and in many cases this will be a question of grave doubt. In this connection it is interesting to note the introduction of several such plants in railway locomotive repair plants during the last few years; this may be due to the present period of activity, which results in extremely high prices and slow deliveries when flanged and riveted parts are ordered from the locomotive builders. Sometimes a compromise is made, the flanging being done by hand, and a riveting plant suitable for firebox work only being provided; a 12-foot stake riveter will then answer, which also requires less head room than the usual 17-foot stake machine for boilerwork. The horizontal dimensions of the riveting tower are largely influenced by structural considerations, but an analysis of several examples shows that a rectangle 20 by 20 feet would be a minimum for a single machine, while a tower for two machines (placed on opposite sides of shop) in one case is about 25 by 70 feet. If the riveting machine is set on the floor the height of tower from floor to lower chord of roof truss should be, for a 12-foot stake machine, from 55 to 60 feet, and for a 17-foot stake machine, from 65 to 70 feet. (Reading is 76 feet, which seems to be excessive.) At Altoona (Juniata shop) the 17-foot stake machine is set in a pit, to reduce height of tower and bring the machine ram down to a level where the work can be handled from the floor.

The floor area in use for boiler and tank shops (considered collectively) ranges from a minimum of 500 square feet per erecting shop stall, in small repair shops, up to a maximum of 4,000 square feet in construction shops. The floor area of the new boiler and tank shops at the Schenectady works of the American Locomotive Company totalizes above 10,000 square feet per stall of the present erecting shop, but these new departments are probably proportioned to correspond to a new erecting shop of increased output. Railway repair shops of good size run from 1,500 square feet to 2,500 square feet per erecting shop stall, according to the variety of work they do, the lower limit being sufficient if fireboxes are made elsewhere, and the upper limit if a few new engines are built while repairs are being carried on.

THE SMITH SHOP.

In the case of the smith shop department of a general railway repair shop it is more difficult to establish proportions, particularly floor space, because it can not be referred to any unit; the boiler shop is engaged almost exclusively on locomotive work, whereas the smith shop is used jointly on work for locomotives, passenger equipment cars and freight equipment cars, and probably on both repair and construction work in one or another of these. Work for the maintenance of way department is also frequently handled in the smith shop. When all our principal American combination shops (that is, those engaged on both locomotive and car work) are listed, it is found that smith shop floor areas range from 7,500 square feet to 75,000 square feet, which limit is slightly exceeded at the new Montreal shops of the Canadian Pacific, where new work, both locomotives and cars, is to be undertaken on a large scale in addition to repair work. Most of our own combination plants, however, show a total smith shop floor area running from 20,000 square feet to 40,000 square feet. The exact amount of smith shop floor space for any projected plant can be approximated only after consideration of all the facts bearing on the individual case.

If 20 feet is adopted as the general head room (where traveling cranes are not used) of one-story structures, there is good reason for increasing it to 22 feet where swing cranes are in general use, as in the smith shop. At the new Collinwood shop of the Lake Shore the smith shop head room is 24 feet. As swing cranes impose horizontal loads on roof trusses, and as these loads may be in any direction, or all in one direction, it is good practice to proportion the trusses accordingly, and to introduce a good system of horizontal bracing. The new Reading shop of the Philadelphia & Reading has a smith shop which is equipped with a traveling crane covering the entire floor space; this is a decided novelty; there are of course swing cranes as well, supported from the walls. An earth floor is the only practicable one for a smith shop.

The tools list will require great care; hammers from 6,000 pounds

down are used; forges, usually in three sizes — light, medium and heavy; furnaces in assorted sizes from the large scrapping furnace to the bolt and spring furnaces. Trade catalogues will make the way easy for selecting hammers and forges, but there is no authoritative source of information in reference to furnaces, which must be designed in imitation of the best practice which can be located and observed. The ideal fuel for furnaces is gas, which is in common use in steel works, but practically unknown in railway practice except for the single example at the Altoona (Juniata) shop of the Pennsylvania Railroad, where a battery of gas producers supplies all the smith shop furnaces, and one in the boiler shop. The use of oil as a fuel, which is quite common in bolt and spring furnaces in railway shops, is a cheap and acceptable substitute for gas, but is hardly applicable to very large furnaces. Where a great deal of scrap is worked into slabs, enough to keep one hammer occupied, it will pay to have two furnaces to feed it, otherwise the work will be interrupted whenever the furnace requires relining or patching, which happens quite frequently.

An examination of the layout plans of a considerable number of smith shops discloses the fact that there seems to be no preferred method of grouping small forges for handwork, but the indications are that such forges should be spaced not less than 15 feet center to center (preferably more), should be ranged along the side of the shop, and stood at an angle to the side wall; this makes the wall available for tool racks, and leaves the finished work lying on the ground adjacent to the gangway, from which it can be gathered up without interfering with the smiths and helpers. Medium and large forges are usually equipped with swing cranes, and can be used to best advantage when located away from walls. The modern smith shop should have both a pressure fan for blast and an exhaust fan to clear away smoke; the down draft system of exhaust has been much used of late, but is susceptible of improvement.

Bolt headers, bulldozers and forging machines are items in the essential equipment of the railway smith shop. These and steam hammers require the use of dies and formers, some of them very heavy; provision should be made for storing them outside the shop, and a hand traveling crane is very useful in this connection.

The general scrap yard should be located near the smith shop, in order that as much wrought-iron scrap may be redeemed as possible. With electric driving available a shear may be located in the scrap yard, and at a few shops a small train of rolls (with heating furnaces) is provided, in order that rods may be rerolled to smaller sizes.

NOTE.—Three chapters devoted to car shops are omitted by your committee. They are exceedingly valuable as a part of the whole work by Mr. Soule, but they are not covered by the instructions for this report.

THE POWER PLANT.

The electric power plant as a feature of railway shop practice is a product of the last ten years, but there are now a sufficient number of

such plants to indicate the general trend of design, and to emphasize those conditions and requirements which are peculiar to the service. Electric power is usually needed for transfer tables, traveling cranes, tools, fans, lighting; in addition to the steam being required as motive power for these purposes, it is also required for air compressors, pumps, hammers and heating; the latter of course only when the supply of exhaust steam is insufficient for the purpose.

The size and capacity of the plant are determined by totalizing the demands for power, both internal and external, to the building. Beginning with the electric generators, their capacity is ascertained by adding the total fan load and total lighting load, and then a percentage of the total rated capacity of motors used for other purposes; this added percentage may range from 30 to 60, according to whether there are few or many traveling cranes, and the kind and frequency of service they are likely to be called on to perform. To the total so arrived at may be added a percentage to cover distribution losses, growth and contingencies, this latter percentage of course being largely influenced by local conditions.

Taking the total generator capacity in kilowatts, but expressing it in horse-power, it is divided by 0.85 (assumed factor of efficiency for direct connected sets) to determine the necessary equivalent engine horse-power, to which is commonly added twenty-five per cent in order to have power available for at least a portion of the overload capacity of the generators. Many railway shop power plants hitherto built have provided a very large excess of power over what has actually been required in service; with the experience now accumulated, this is not so likely to recur in the future.

The boiler capacity may be worked out by assuming a rate of steam consumption suitable to the size and type of engine to be used; under present conditions it is probable that the steam consumption per horse-power per hour should be taken somewhere between 15 pounds and 20 pounds, according to the degree of refinement in the engine design. Fifteen pounds seems far in excess of the 9-pound minimum which has been recorded in a few cases in exceptional plants, where triple expansion was used with superheaters and reheaters; but 15 pounds is a fair minimum for purposes of estimates for every-day service under commercial conditions, as compound non-condensing engines are what we now generally find. It is probable that the future has something better in store for us, but we are dealing with present conditions.

Unfortunately boiler horse-power and engine horse-power are not synonymous terms, as a boiler horse-power is simply the capacity to evaporate 30 pounds of water into steam from temperature 100 (degrees Fahrenheit) to a pressure of 70 pounds (per square inch), and this fact has to be borne in mind when estimating boiler capacity corresponding to any given engine capacity. To the boiler horse-power thus obtained must be added the necessary excess to furnish steam for hammers and possibly for heating, also to drive air compressors, pumps or other auxiliaries; the steam consumption rate for auxiliaries will often be two, three or even

four times as great as for the main engines, even under what passes for good practice. The lighting load of a railway shop power plant is usually assumed on the basis of one horse-power to each arc light, and one horse-power to each ten incandescent lights.

The subdivision of generating units and boiler units can best be accomplished by charting the expected total load through a period of twenty-four hours, and then so selecting the units as to permit of such combinations as will secure full loads, or as nearly so as possible at all times. Engines and generators are not here assumed to be disabled and unfit for service except in emergencies, but boilers will be out of service periodically for cleaning and repairs, and excess capacity must be provided to cover.

In providing means to drive electric generators we have the opportunity of choosing between the steam engine, the steam turbine, and the gas engine, with increasing thermal efficiency in the series. With conditions as already outlined a unit larger than 750 horse-power is seldom required in railway shop power plant practice; this is a little small for best results in steam turbine practice, and a little large for comfort under present conditions of gas engine practice. Steam turbines are actually installed in one plant (Aguas Calientes, Mexico, see *American Engineer,* page 466, December, 1903), while gas engines were contemplated (but not actually used) in a Western plant; meantime current practice has gravitated to the use of compound non-condensing engines, usually horizontal (because floor space is seldom limited), and always automatic, that is, with governor regulated cut-off; condensing apparatus is found in one case only, at the West Milwaukee shop of the Chicago, Milwaukee & St. Paul Railway. Gas engine predictions are risky, but a constantly increasing use of the steam turbine may be expected, with condensers as an economical adjunct. When this comes about, power plant buildings can be made of reduced proportions.

Water-tube boilers will usually be preferred to fire-tube boilers for several reasons: They are much safer to operate (an explosion being limited to a single tube); they take up less space for a given capacity; they are quicker steamers; scale can be removed from interior of tubes by power devices and cheap labor, whereas fire-tube boilers must have tubes removed by high-priced labor in order to remove scale; and also the boiler will be much longer out of service. These advantages outweigh the greater cost, and the fact that the ratio of water capacity to steaming capacity is small, which means that water-tube boilers do not always respond as well as fire-tube boilers when there is a sudden and excessive demand for steam; but the net results are in favor of the water-tube boiler which is now generally used.

There being several makes of water-tube boilers, all of high efficiency, the choice will usually be determined by commercial considerations. For [illegible] steam consumption in unit time the water level will fluctuate more [illegible] vertical than in a horizontal boiler, and the feed regulation [illegible] closer attention; on the other hand a boiler-room fitted with [illegible] will be cooler than one fitted with horizontal boilers, and

therefore more comfortable to work in — quite an advantage in hot countries. It is one of the anomalies of power plant practice that the thermal efficiency of steam boilers often approximates to seventy-five per cent, while that of steam engines seldom exceeds fifteen per cent.

Mechanical stokers will be a source of economy in fire-room labor in boiler plants of from 1,000 horse-power up, and will minimize boiler repairs in a plant of any size, even if considerably less than that; fuel will be used to the best advantage, and smoke reduced to the lowest limit. Feed-water heaters are of proved value as a means of rescuing waste heat from exhaust steam, but in winter must usually divide honors with the heating system.

Mechanical draft systems have been perfected so as to be thoroughly practicable and reliable. The fans are usually provided in duplicate and fitted with water-cooled bearings; and when the system includes the automatic draft regulator, the amount of draft corresponds to the steam pressure. The whole makes a very flexible arrangement, increases the rate of combustion and evaporation and reduces the size and cost of boiler plant required to produce a given horse-power; saves first cost, and, therefore, interest, insurance and taxes; greatly reduces size and cost of stack; these several savings much more than offset the corresponding items for the mechanical draft plant together with its cost of operation and maintenance, and result in a net saving. Four tests have been recorded where mechanical draft produced boiler horse-power (on basis of 34.5 pounds of water from and at 212°) fifty-five per cent in excess of rated capacity; this illustrates the flexibility of the system; the draft produced by a chimney without mechanical auxiliaries is proportional to the square root of its height, which means that the same result produced by natural draft would require a chimney nearly two and a half times as high as the original chimney (provided its diameter was not also increased).

Economizers do not always economize under railway shop conditions, where coal is always cheap as compared with its cost under usual manufacturing conditions, and they are regarded as a refinement a little beyond our immediate needs.

The use of power devices for handling coal and ashes depends largely on local conditions. If a trestle can be arranged alongside the boiler-room without interfering with or sacrificing other yard arrangements, it will usually be found that expensive and complicated apparatus are not warranted, and the very simplest home-made mechanical appliances will yield the desired measure of economy; this is true even when mechanical stokers are used, when it of course becomes necessary to elevate the fuel to the level of their hoppers.

The piping of a modern power plant is a critical feature. Boiler pressures have advanced from 80 pounds to 150 pounds in the past twenty years, and now all pipes, fittings, pumps and engines are required to stand 200 pounds. Copper pipe has disappeared from practice as treacherous and unsafe material. Steam pipes of to-day are of wrought iron or wrought steel, and often with cast or forged steel flanges, which may be either

screwed, riveted or welded on, and sometimes with faced joints. Expansion is taken care of by long bends or by swing joints; the old style slip joints and corrugated copper joints have almost entirely disappeared; the development and introduction of separators, with their receivers or reservoirs, and the gradual introduction of higher pressures, have had their effect in reducing the size of steam pipes, and it is now not unusual to see a steam pipe smaller than the admission pipe to the engine.

The choice of current and wire system for a railway shop power plant is affected by many considerations, among which are the following: Transmission, whether short distance, or long distance, or both; speed of motors, whether constant, or variable, or both; lighting, whether arc, or incandescent, or both; and whether confined to the immediate locality or extending to outlying and remote points. The relative merits of direct and alternating current for distribution are summarized in Table 15, which, however, is susceptible of much further elaboration and refinement.

The facts that our shop problems are constantly growing larger, that power plants are supplying electrical energy (whether for power or light) for increasing areas, that the steam turbine has great advantages (particularly for high-speed work) over the reciprocating engine, and that there is somewhat of a reaction from the excessive use of complex and costly variable-speed apparatus, all point to the conclusion that alternating current generating apparatus will be the prevailing practice in large installations in the future, with auxiliary apparatus for converting a portion of the primary alternating current into direct current for those applications where it is to be preferred. The Reading shop power plant of the Philadelphia & Reading Railroad is a notable example, and almost the only one, of the use of both currents with the alternating as the primary; in this plant the rotary converter is of course used, but the development and perfection of the Cooper Hewitt static converter (for transforming alternating current into direct current) may lead up to the complete elimination of the rotary converter.

Although it is believed, as has been intimated above, that variable speed has been somewhat overdone, yet for those cases where it ought to be used, a choice of method must be made. Of all the alternatives it seems that three might be eliminated at once, namely, resistance in the armature circuit (because of wastefulness and inefficiency); the double commutator (on account of cost and complication), and the four-wire multivoltage system (also on account of its cost and complication). This leaves the two-wire single-voltage system, with adjustable resistance in the field circuit, and the three-wire two-voltage system, combined with field control; and it is believed that future practice in railway shop power plants will be limited to these two systems.

The power plant building being the nerve center of the modern shop, and representing, with its contents, an investment of from $75,000 to $150,000, should be fireproof and isolated, the change from mechanical to electrical transmission having made such isolation practicable. A rect-

angular building approximating to a square easily subdivides into engine-room and boiler-room of nearly equal floor area, as required. It generally happens that the floor of the boiler-room can be depressed below general ground level to good advantage (where sewerage conditions permit) in connection with handling the coal supply; on the other hand the floor of the engine-room can be established several feet above the ground level, with a basement for piping and accessories, such as pumps, heaters, condensers, air reservoirs, etc. In many plants too little head room has been allowed in the engine-room basement, which should preferably be roomy, airy and well lighted. In the power plant of the Baring Cross, Ark., shop of the Missouri Pacific Railway, all the auxiliary apparatus has been assembled in what is termed a pump-room, which is 16 by 75 feet, open to the roof and interposed between the engine-room and the boiler-room; this arrangement screens these rather unsightly accessories from the more ship-shape and tidy engine-room, and also protects the wearing surfaces of pumps, etc., from the dust of the boiler-room.

Table 16 embodies the principal data for eighteen shop power plants, and fairly indicates their size and capacity:

TABLE 15.—RELATIVE MERITS OF DIRECT AND ALTERNATING CURRENT FOR ELECTRICAL DISTRIBUTION FOR RAILWAY SHOP POWER PLANTS.

Item.	Direct.	Alternating.
Generators	Commutator, with attendant troubles.	No commutator.
Engines	Reciprocating (the speed of generators being limited)	Turbines may be used, as generators can be successfully run at turbine speeds.
Motors	Must have commutators, but may be made to yield variable speed by either of several methods	Induction type, without commutators, but constant speed.
Lighting (arc and incandescent)	May be accomplished with either current, but direct current is simpler and preferred.	
Conversion (to other kind of current)	By machine (rotary converter or motor generator).	By machine at present, but probably by static apparatus in future.
Transformation (to higher or lower voltage, but same kind of current)	By machine (seldom done)	By static apparatus.
Transmission	Feasible for moderate distances, but (voltage being limited) cost becomes prohibitive for long distances	Feasible for moderate distances, and the only commercially practicable system for long distances.

Reading, Pa., is seen to be the most extensive plant so far put up. It will be noted also that alternating current is used to some extent in six places. The reason that the kilowatt capacity of generators and the horsepower capacity of engines vary so much in plants which, judging from the size of buildings, appear to be intended to provide approximately equal amounts of power, is that the individual opinions of the designers vary so much on the question of what spare units should be provided. There is a noticeable tendency to fully double the voltage when alternating current is used, as compared with that used with the direct current; this is probably due to the fact that, as alternating current induction motors do not have commutators, brushes, slip-rings or collectors, employees have no occasion to handle them, and the risk of shocks is therefore minimized.

Switchboard design has become a specialty, in which it is well to let the specialists take the responsibility, and it is a poor place to curtail. The fundamental requirements are: complete isolation of circuits, automatic circuit breakers for overloads, separate panels and recording instruments for each principal circuit, etc.

NOTE.— At this point three of Mr. Soule's chapters are omitted. These refer to the storehouse, foundry and roundhouse. While exceedingly important they do not seem germane to the subject of your committee. Emphasis, however, should be placed upon Mr. Soule's suggestion of the importance of efficient tool equipment for roundhouses.

THE LAYOUT.

After deciding on the floor areas and general features of the several departments which are to be included in the plant, their relative arrangement and track connections (collectively termed "the layout") have to be considered. In a general repair plant there are two groups of buildings, for locomotive work and car work respectively, and often some buildings common to both. A single building may, and generally does, contain more than a single department, and the relations between the departments largely influence the grouping of the buildings. The principal departments of the locomotive group are the erecting shop, the machine shop, the boiler shop, the smith shop, and the storehouse. It is believed that under average conditions the amount of business interchanged between these five departments should justify favoring facility of intercommunication in the following order: (1) Erecting and machine; (2) erecting and boiler; (3) machine and smith; (4) boiler and smith; (5) machine and boiler; (6) erecting and smith; (7) machine and storehouse; (8) erecting and storehouse; (9) boiler and storehouse; (10) smith and storehouse. It is assumed that the stock of boiler plate, although under storehouse jurisdiction, is kept at or near the boiler shop, and, similarly, that the stock of bar iron is kept at or near the smith shop.

The following are some of the principal points to be borne in mind in connection with the general problem of the railway shop layout:

1. A longitudinal erecting shop is parallel to the base line of tracks, and does not require either a turntable, transfer table or fantail, for its approach.

2. A transverse erecting shop, if its stall tracks are to be parallel to the base line, must be approached either by a fantail or by a transfer table.

3. A transverse erecting shop, if its stall tracks are to be at right angles to the base line, must be approached by a turntable.

4. Buildings should be so arranged that each may be extended by a large fraction of its original size. In the case of separate departments within the same building, permanent barriers between them should be avoided, so that the original assignment of space to each may be modified to suit altered conditions.

5. All buildings (or departments, or bays of buildings) which are to have traveling crane service, should, in order to get maximum results from the investment, be relatively long and narrow.

6. Each principal department should have yard room (which it can control) adjacent to it.

7. The track system should be so arranged that tracks between principal buildings should simply be running tracks, and not standing tracks on which strings of cars may be left.

8. Outside tracks should not be so close to buildings that cars left standing on them will block off the light from any portion of the interior of a building.

9. Avoid placing 8-foot turntables (for hand trucks) in running tracks which are to be used by locomotives, and, whenever possible, place such turntables under traveling cranes, facilitating their removal when pits have to be cleaned out.

10. A yard crane should have a surface track parallel to and between runways, and connecting to tracks leading into buildings. Such a track will be very serviceable when the crane is either busy or out of service.

11. The roundhouse (if any) should be accessible from machine shop and boiler shop; accessibility from the smith shop is not so important.

12. The oilhouse, when possible, should be between and easily accessible from the roundhouse and the storehouse.

13. If a transfer table is necessary (as it probably will be at the passenger car shop) it should preferably be located at one edge of the property, so as to impede general yard traffic as little as possible.

14. If the shop group is in sight of the main passenger tracks, engines and cars awaiting repairs should be kept behind the buildings.

15. The original layout should include all yard accessories, such as scrap bins, lavatories, miscellaneous storage, lumber yard, etc.

16. The power plant should be central as regards power distribution, but should be isolated as a precaution against fire.

The relative merits of the longitudinal and the transverse erecting shop, considered from a construction and operating standpoint, have already been discussed, but the longitudinal shop lends itself more readily to the average layout conditions, and eliminates both the turntable and the transfer table (as regards the locomotive group of shops) from the problem, and these are generally realized to be obstacles in the way of simple and direct track connections. As regards the extensions of buildings it is well to group the original structures as near to one another as circumstances permit, and to reserve space for their extension outwardly from the general center. The best evidence that transfer tables are apt to be an obstruction to traffic is that in several cases they have been installed and subsequently removed, as, for instance, at the New Haven, Conn., car shops of the N. Y. N. H. & H., and at the Juniata, Altoona, Pa., locomotive construction shops of the Pennsylvania Railroad.

Scrap bins have too often been left to chance and have been wedged in in cramped quarters after the buildings were completed and the plant put in operation; but discussion in the railway clubs and elsewhere during the last five years has focused attention on the problem and led to a better state of affairs, so that in some few cases (Collinwood, for instance) the scrap storing, handling and shipping facilities have been made part of the general scheme from the beginning, and installations worthy of the importance of this branch of current business have been put in. A power shear is a very useful adjunct, and machines for straightening bolts and rethreading them can usually be kept busy; practice tends toward keeping the scrap bins within easy reach of the smith shop, without, of course, sacrificing its relations to other departments from which it receives its principal contributions of scrap. Similarly, the smith shop foreman is often given a supervisory or advisory jurisdiction over the scrap platform, as being likely to be the best judge of what materials may be redeemed and used over (with or without having work done on them, as the case may be), what may be worked up into heavy forgings in the smith shop, and finally, what should be listed and reported for sale. If there is a traveling crane in the yard an effort should be made to so locate it or so locate the scrap bins as to make the crane of service in handling scrap; it is especially useful in unloading tangled wreckage as it comes in off the road, and may also be availed of in loading scrap for shipment, if certain other minor facilities are provided.

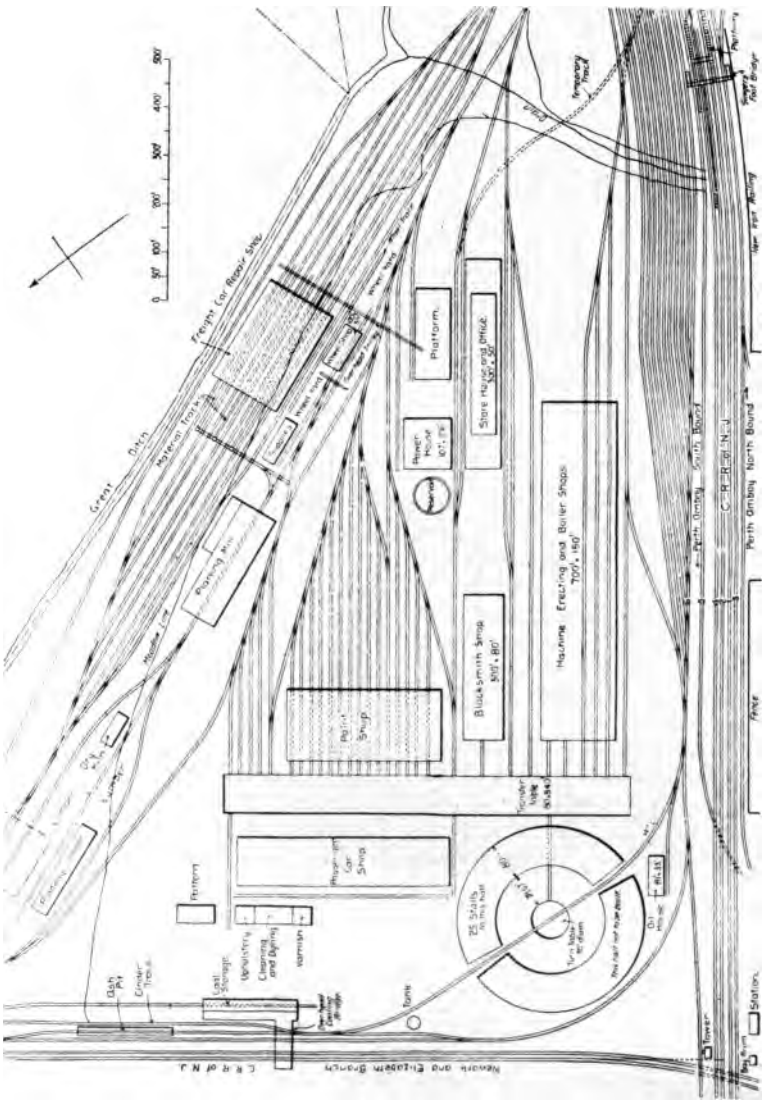
The use of 8-foot turntables outside of buildings is objected to by many and for various reasons: First and most important, because they must be excluded from all tracks over which locomotives are likely to pass, and, second, because their pits are likely to at times fill up with dirt, or be frozen up, and the turntables thus become inoperative. On the other hand, they permit of much more direct truck track connections than any system of switches possibly can, and trucks will make better time over them than over switch connections, as in the latter case the truck must be left while the switch is being turned in more than half the movements. Further, if

the pit masonry is heavy, carried well below the frost line, and the pit provided with ample drainage, the time the turntable will be out of service will be a very small fraction of working hours, if any. Those 8-foot turntables, which are under a yard crane, are easily lifted out when there is work to be done in the pits, and at the new Montreal, Can., Angus shop plant of the Canadian Pacific, there are seventeen 8-foot turntables located under the yard crane, while there are several more which are not covered by the yard crane. At this plant the drainage conditions are exceptionally favorable, and inasmuch as the snow fall is maximum, the practical results which may be realized from the use of this installation may be appealed to with confidence.

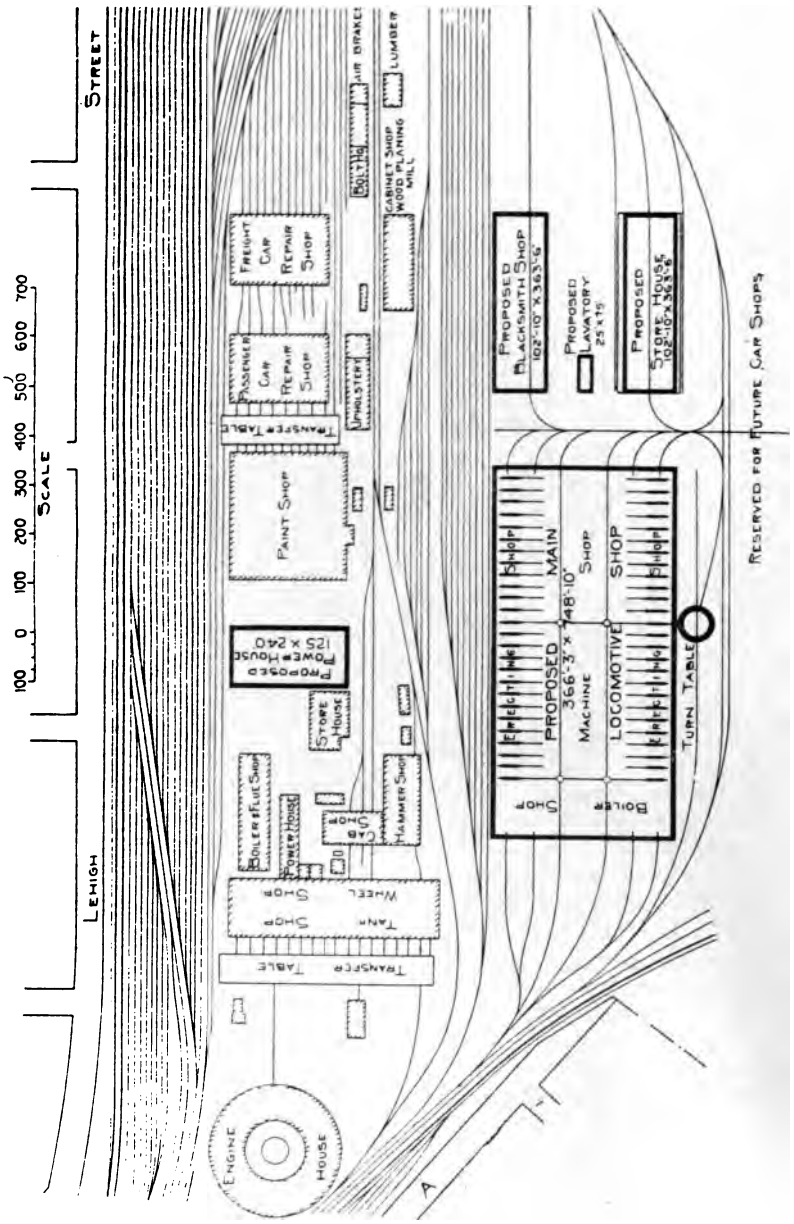
Layout plans of Elizabethport, N. J. (C. R. R. of N. J.); Sayre, Pa. (L. V.); Topeka, Kan. (A. T. & St. F.), and McKees Rocks, Pa. (P. & L. E.) are submitted herewith, as a basis of comment. Longitudinal erecting shops are used at Elizabethport and Topeka, transverse erecting shops at Sayre and McKees Rocks. Elizabethport and McKees Rocks are new plants throughout; Sayre and Topeka are each a combination of old shops and new shops.

Elizabethport presented a peculiar problem, as the available land took the shape of a right-angled triangle. As the roundhouse was to serve both the main line and the two diverging branches (only one being shown in the plan) the rectangular corner of the property was naturally the preferred location for it, and this fixed the oilhouse as adjacent to it. The erecting and machine shops were obviously to be kept as close as possible to the roundhouse, as in this case the roundhouse has no machine shop annex of its own. Other considerations suggested that the transfer table be interposed between the roundhouse and the main shop, but this somewhat hinders foot traffic between the two, and also leaves the boiler shop, which always has very intimate relations with the roundhouse, rather far away from it. The smith shop falls into place nicely as regards the main shop building, and has very good connections with the passenger shop, freight shop and storehouse. The storehouse is somewhat out of the center of gravity, but has good track connections and shipping facilities; the power house is centrally located as regards power consumption; the transfer table pit is one of the largest in the country, others are longer and narrower, but none has a greater ground area. The passenger car buildings are naturally grouped about the transfer table, the cabinet shop, for convenience, being located in one end of the passenger repair shop, rather than at the more remote planing mill. The paint shop stall tracks are reached from the transfer table only, the yard tracks on the opposite side of the building not running into it. The freight repair facilities include a building and have the planing mill close at hand, the cabinet shop being elsewhere, as is also the case at the new shops of the Pennsylvania at Wilmington, Del. It can be said of Elizabethport that it is possible to extend each individual building in a large ratio.

Sayre was a problem where a very large increase of locomotive repair



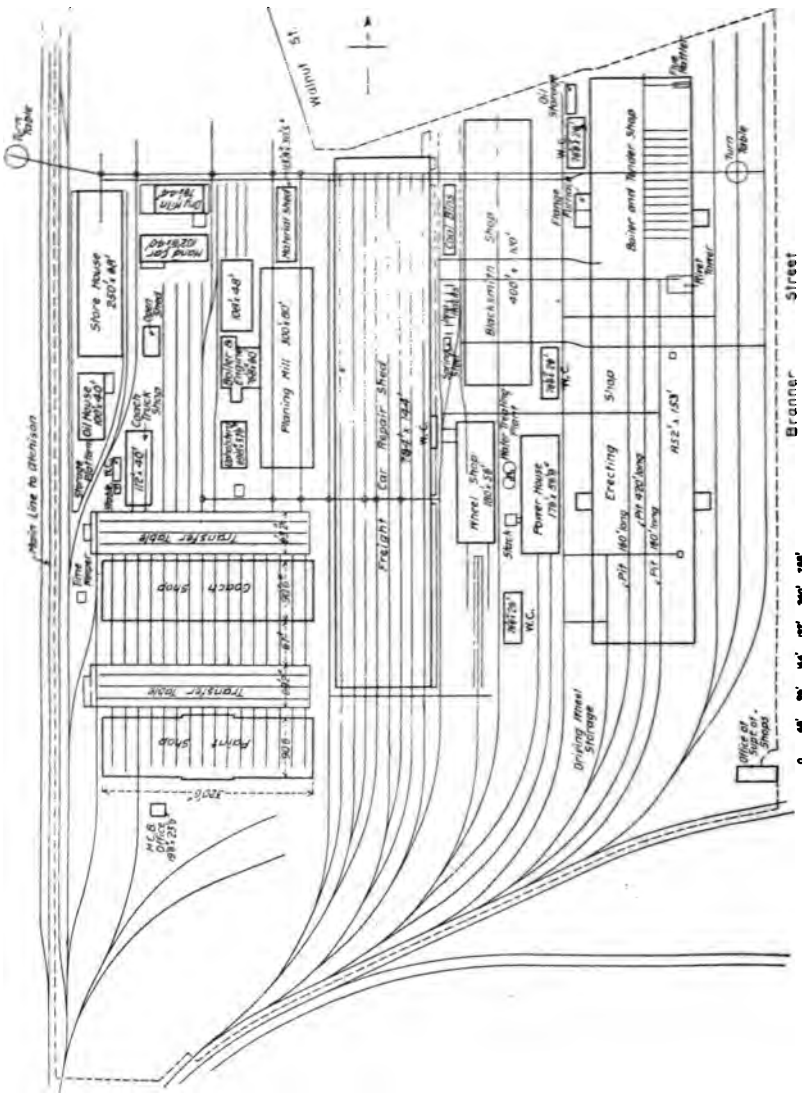
ELIZABETHPORT SHOPS, CENTRAL R. R. OF NEW JERSEY.



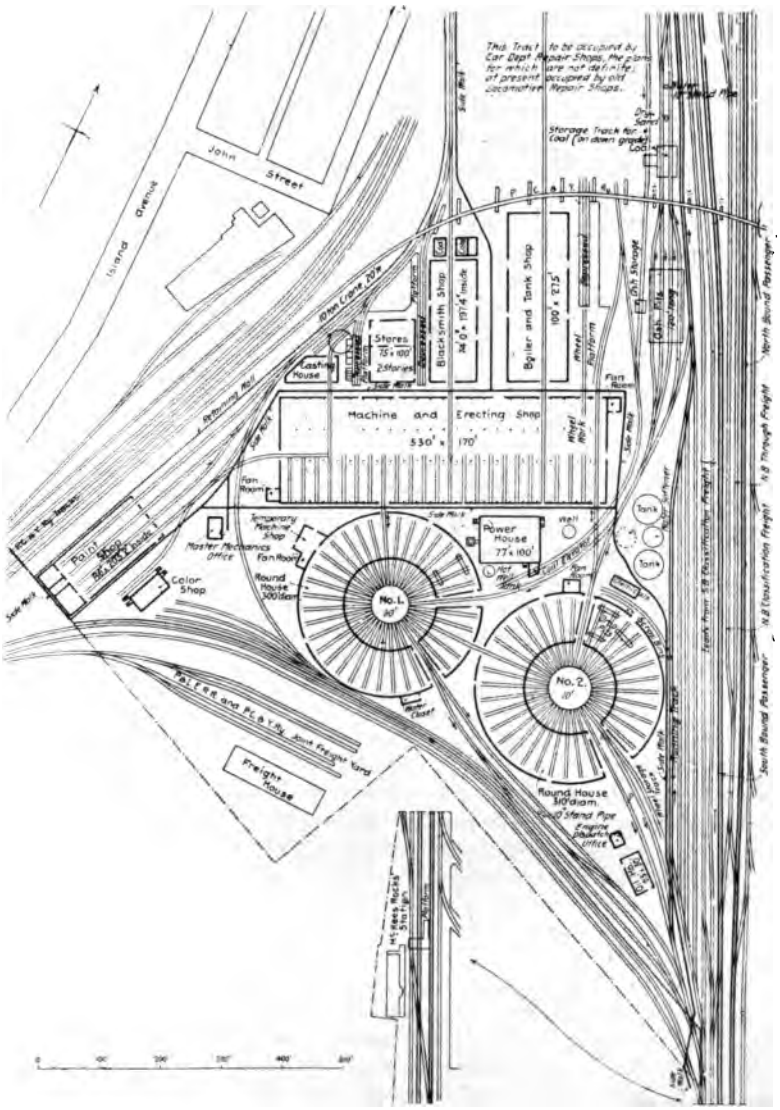
SAYRE SHOPS, LEHIGH VALLEY R. R.

facilities was imperative. Efforts were made to provide additional structures within the limits of the original shop property, but, as this proved to be impossible without undue congestion and forbidding all future extensions, additional and adjacent property was acquired. Four new buildings house the erecting shop, machine shop, boiler shop, smith shop, storehouse and power plant, and the work still remaining in the old buildings had to be redistributed. The new main building has track connections into each of its several crane served bays from both ends of the building; those at one end can evidently be used either by locomotives or by hand trucks; those at the other end by hand trucks only. The two erecting shops being of the transverse type, with the long side of the building placed parallel to the track base line, access by turntable was necessary, and the engines after being taken in are lifted over one another to be placed in the repair stalls. The use of 8-foot turntables outside of buildings has been avoided, and a system of curves and switches substituted by which hand trucks may pass between the three buildings and the six bays of the main building; the storehouse being over 100 feet wide, the central through track will be very serviceable in the way of placing road cars in the center of the floor space for loading and unloading, and not less so in making it possible to run hand trucks in from the shop side as well. It will be noticed that a large lavatory building is to be provided in a space between buildings, but it is not known whether other lavatories are to be provided inside some of the buildings as well.

Topeka was also a problem of enlargement, the available land being across the main tracks from the original shop location. On account of the peculiar shape of the property, the several longitudinal buildings have track connections from one end only, and in order to avoid the necessity of keeping the center track of the erecting shop always open through to the boiler and tender shop, a turntable is introduced by means of which tenders may be brought into the boiler and tender shop direct, and it naturally follows that the tenders or their frames or tanks, when lifted into working position, are stood transversely to the length of the building. The exigencies of the particular case made it necessary to have the power house long and narrow instead of the more prevalent type of a building nearly square, which is usually preferred, where possible, as it minimizes pipe connections and presents some other advantages. The smith shop, while favorably located in reference to those other departments which it principally serves, apparently can not be extended. It will be noticed that the wheel shop has a depressed track adjacent to it to facilitate loading and unloading mounted wheels. The freight car repair shed is a fine example of liberal provision for this class of work, and it covers nearly the whole of the freight repair yard. In the passenger car group of buildings the unusual feature is the use of two transfer tables where one would seem to have answered for the coach shop and paint shop, but possibly the second one is intended to give access to the planing mill, the coach truck shop, and the intermediate yard tracks. Owing to the peculiar conditions of this layout, several cross connecting



TOPEKA SHOPS, ATCHISON, TOPEKA & SANTA FE RY.


This Tract to be occupied by Car Dept Repair Shops. The plans for which are not definitely prepared. At present occupied by old Locomotive Repair Shops.
Storage Track for 4 Coal Cars down grade
John Street
Island Avenue
Stores 75 x 100 2 Stories
Blacksmith Shop 36'0" x 131'4" Inside
Boiler and Tank Shop 100' x 275'
Machine and Erecting Shop 530' x 170'
Wheel Platform
Fan Room
Casting House
Tank
Power House 77 x 100'
Temporary Machine Shop
Master Mechanics Office
Round House 100 Stalls
No. 1. 80'
No. 2. 70'
Paint Shop
Color Shop
Freight House
Round House 50' diam.
Engine Foreman's office
Pit Track
Sand Pipe
Coal Chute
Water Column
Tank
Tank
Tank
Fan Room
Fan Room
Fan Room

tracks are required, and it is understood that some of them are provided with pneumatic jack turntables at crossings, which cause no break (other than frogs) in the track rails.

McKees Rocks is a very interesting layout in many particulars. The first thing that attracts attention is that the roundhouse accommodations are unusually liberal in proportion to the size of the shop; next it is observed that the entire available property is occupied from the outset, there being no chance for the expansion of any building in any direction. This probably results from the fact that level tracts of land are very scarce at or near Pittsburg (McKees Rocks being only four miles out) which traffic conditions fix as the natural and preferred shop location. To secure the results aimed at, the distance between the main building is reduced to 25 feet in several instances, while in a few instances it is even less than that. This ought to be taken as a valuable precedent, as it is always advisable to keep shop buildings as close together as possible, and with modern steel and brick construction and improved fire precautions it is certainly practicable to relax somewhat from the rigid conditions imposed by insurance companies in the days when wood was more largely used in building construction and the modern concentrated shop power plant had not been evolved, the latter being almost always equipped with large and powerful underwriters fire pumps, with steam up and skilled attendants on hand at all times. Other noticeable features are that each roundhouse has two sets of approach tracks, that the ash pits cover four tracks, that the oilhouse is located with reference to the roundhouse rather than the storehouse, that there are three depressed tracks (one for handling mounted wheels and two alongside of the storehouse) and that the passenger car paint shop is of the longitudinal type.

CONCLUSIONS.

The several subdivisions of the general subject which have been dealt with will be mentioned seriatim, in order that each may be commented on, and additional information (if any) introduced.

The Erecting Shop.— Table I in the original article gave 24 feet 9 inches as the greatest spread (center to center) of tracks in the longitudinal shops there listed, but attention was called to the fact there had been a tendency toward progressive increase in that spread. Since that time several shops of 25-foot track spread have been mapped out, and it is known that one road has at least considered a spread of 30 feet (the building being 90 feet wide) for the three main longitudinal tracks, intermediate dummy tracks being provided simply for use in wheeling and unwheeling engines. This arrangement would bring into permanent use for standing engines the entire length of each of the three main tracks, and would require only about 1,350 (30 by 45) square feet of floor space per engine, as compared with the minimum of 1,300 square feet given in Table IV for a transverse shop even under the most favorable conditions.

In the case of transverse shops it was stated that a width of 65 feet

between crane runway columns was sufficient, but this statement should be qualified. If in the design and arrangement of the erecting shop suitable and sufficient space has been reserved for engine truck repairs at one end of the building, but still under the main crane runway, so that engine trucks may be dropped into that space by the crane, then a span of 65 feet between crane runway columns is quite sufficient; but if, as in some recent new shops, the whole floor space is given over to stalls in which engines are to be stood, it then becomes necessary to repair each engine truck on the track where its engine is standing, and under those circumstances a span of 65 feet will be found too scant, and it should be increased to, say, 70 feet. In the evolution of the modern transverse shop from the old one there has been a tendency to reduce the width below a comfortable working limit, as by so doing the length and depth (and therefore the cost) of the overhead crane or cranes is kept down to a minimum, and similarly the height of the building up to the lower chord of the roof truss. In the case of the old-style transverse shop, with its cheap timber truss roof, always with minimum head room for any span, there was not the same incentive to curtail the span, and therefore those old shops are remembered as comfortably roomy.

The U. P. shops at Omaha, Neb., and the O. S. L. shops at Pocatello, Idaho, afford an interesting comparison of erecting shops, the same cross section of building (combined erecting and machine shops) being used at both places, but the Omaha erecting shop is longitudinal, while that at Pocatello is transverse.

New longitudinal erecting shops have been put up by the Pennsylvania Lines to replace old transverse shops at Columbus, Ohio, and Fort Wayne, Ind.; in the latter the overhead cranes have a capacity of 75 tons each (with two auxiliary 10-ton hoists), a notable advance from the previous 65-ton limit. Another valuable feature of the Fort Wayne arrangement is that the wheel lathes and similar tools are located between the erecting and boiler shops under the sweep of the erecting shop cranes; this practice, originally introduced at the Juniata (Altoona) locomotive building shop, is being incorporated into the design of the latest Pennsylvania repair shops, as at Fort Wayne and Wilmington, Del. Fort Wayne also differs from Columbus in having longitudinal storage pits under the floor between tracks.

The new transverse erecting shop of the New York Central at West Albany has a span of nearly 70 feet between crane runway posts and therefore has ample room for both an engine and its truck on each track, besides which there is an additional space of 20 feet under a gallery, the building having a span of 90 feet. The crane arrangement is peculiar, as there are two 60-ton cranes instead of the more usual single 120-ton crane. When engines are being wheeled or unwheeled both are in requisition, and at other times each may work separately, giving double service and quicker movement. As far as known this is the first case where this arrangement has been adopted in a completely new transverse shop,

although it had previously been resorted to (as at Bloomington, Ill., on the C. & A.) to make possible the introduction of overhead traveling cranes in an old shop where the head room was limited; with this arrangement, when the two cranes are lifting an engine only bottom yokes are required, and vertical space is saved.

The new double transverse shop of the Lehigh Valley at Sayre, Pa., will probably be put in use late this year and will attract a great deal of attention on account of its great size (48 stalls), the provision of covered yards, and the extension of the erecting shop and machine shop crane service into the boiler shop; it will also have a system of pits (in the covered yards) for the storage of engine strippings.

The new Moline, Ill., erecting shop of the C. R. I. & P. is unusual in many respects; it has a span of 95 feet, the unusually wide shop of the N. Y. C. at West Albany being 90 feet, as above mentioned. It has separate systems of pits for respectively stripping, repairing and wheeling engines, the first and last being longitudinal, while the repair pits (38 in number) are neither longitudinal nor transverse, but are of a sort between these two types and on the herring-bone plan. This arrangement constitutes a new type of erecting shop, and the output results will be a valuable guide to future practice.

The new plant of the Locomotive & Machine Company, of Montreal (now belonging to the American Locomotive Company) has an erecting shop of the longitudinal type, and stands alone in this respect among American locomotive building shops which are engaged in manufacturing for the railways in general, although a similar shop is found at the Juniata (Altoona, Pa.) construction shop of the Pennsylvania.

At Jackson, Mich., on the M. C., is found both a transverse and a longitudinal erecting shop, in the form of a T, which are worked jointly as one shop.

The new Danville, Ill., shop of the C. & E. I. has a transverse erecting shop with both a heavy (80-ton) overhead crane and a transfer table, an unusual arrangement; in this case the overhead crane is used only for wheeling or unwheeling engines, or handling boilers, or any lighter work, the engines being moved in and out of their stalls over the transfer table. The shop has a span of about 74 feet between crane runway posts, but a considerable portion of this is taken up by a fringe of heavy tools and a longitudinal track, so the actual working space in the width of the shop is reduced accordingly.

The Machine Shop.— It was stated that average conditions did not suggest the necessity of covering more than about one-third of the floor space with traveling crane service, but it is proper to state that some examples of very recent practice greatly exceed that limit; for instance, Sayre, Pa. (L. V.), seventy-seven per cent, and Moline, Ill. (C. R. I. & P.), fifty-four per cent. On the other hand, in a large new shop which an Eastern line has under consideration this ratio is forty per cent, while at Danville, Ill. (C. & E. I.), it is about thirty-three per cent.

Several complete tool lists have been published, and the data thus supplied, together with additional data which is probably forthcoming, will form a basis from which new lists may be compiled in the future.

The new St. Paul (Minn.) shop of the Great Northern has no traveling crane service whatever, and as the roof trusses are inclined from the horizontal (lower chord included) the shafting is hung almost entirely from three lines of wooden posts.

The Moline machine shop tool layout at once attracts attention on account of the large proportion of tools which are placed transversely to the longitudinal axis of the shop; this is made possible by the individual drive and the group drive, as in the latter case a single transverse shaft can serve a considerable number of small tools. This arrangement often gives much better access (from the main longitudinal aisles) to individual tools than under the old system (before electric driving was introduced), when all tools had to be ranged in lines parallel to the main shaft.

The Sayre machine shop will be notable on account of its liberal proportions and its superb day lighting, as its entire floor area, together with the two adjacent covered yards, the whole forming a rectangle 240 by 260 feet, is to be covered by a sawtooth roof; tire-shrinking floors and lye vats, with proper drainage features, are introduced at two central points. In very large plants it becomes burdensome to have to handle work of this character outside of shop buildings; at Sayre these lye vats being of ample size and coming under traveling cranes, it is to be expected that driving wheels on their axles can be treated as readily as smaller parts.

The Boiler Shop.— The capacity of a traveling crane for general floor use was assumed to be 35 tons, and that for a riveting tower crane 25 tons; recently, however, the American Locomotive Company has finished the boiler for the new B. & O. Mallet articulated compound, and it is found to weigh completed with flues 42 tons, and without flues 28½ tons, which suggests a readjustment of crane capacities if such engines are to be reproduced in the future.

In the extended and rearranged boiler shop of the Juniata (Altoona, Pa.) plant of the Pennsylvania the relocated 17-foot stake hydraulic riveter is placed in a pit as before, with ram at a convenient height above floor level, but the old hydraulic crane has been replaced by an electric crane; the operator stands alongside of the riveter and with his left hand works the ram valve lever, his right hand being available for working the handles of three adjacent controllers (of the street car type) by which he can control the three movements (two horizontal and one vertical) of the tower crane to a nicety.

Sayre is almost the only transverse shop which has its boiler shop arranged as a prolongation of the erecting and machine shops with joint crane service throughout; this will give the Sayre boiler shop the use of two 120-ton cranes and six 15-ton cranes, and it will be unique, as regards crane facilities, among American railway repair plants.

Moline, a longitudinal shop, with erecting shop bay in the center and

machine and boiler shops on either side, divides its boiler and tank work, placing its riveter in one end of the erecting shop bay so as to get joint crane service between the two, and reserving the wing (which is served by an independent through track) for tank repairs, and work on the lighter attachments of boilers.

The new boiler shop of the C. & E. I., at Danville, Ill., has traveling cranes covering its entire floor surface; the main bay has a two-trolley 20-ton crane which would seem rather light for heavy boilers even now in use; the crane in the side bay, for light work, is of 3 tons capacity; the stalls are reached by the transfer table, which is joint to erecting and boiler shops, the two being in separate buildings.

The Smith Shop.— It was stated that on account of the general use of swing cranes in smith shops it was advisable to provide head room (from floor to lower chord of roof truss) of at least 22 feet, and attention was called to the fact that Collinwood was 24 feet; since then a tendency to increase this height has been noted, probably to secure better results in the way of clearing the shop of smoke, Moline being 25 feet 6 inches and Wilmington, Del. (P. R. R.), being made 33 feet in imitation of Juniata; the new smith shop at Sayre is, however, 20 feet.

A fine example of smith shop roof construction, with horizontal bracing fully developed, is found in the case of the new Topeka, Kan., shop of the A. T. & S. F.; this feature is so often overlooked and neglected that this particular case is worthy of note (see illustration on page 378 of the *American Engineer* for October, 1903).

A very complete equipment of fourteen oil furnaces of various sizes and for different purposes has been installed at Moline; the building is not fully occupied at present, as it is proportioned to take care of the work of both the locomotive shops and the car shops, the latter not yet having been built, however.

The Wilmington smith shop has very broad and very high windows, and a large proportion of doors; in this case the object was not so much to secure light as to make it possible to keep the shop comfortably cool in hot weather.

The Power Plant.— At Moline, Ill., the C. R. I. & P. have put up a power plant in connection with their new shops which has several noteworthy features. The installation includes economizers and induced draft apparatus which naturally go together, but does not include condensers, which arrangement provides for utilizing the waste heat from the boilers, but not that from the engines, but no doubt all the exhaust steam will be used for heating purposes, and possibly water for condensing purposes would have been expensive, as the pumping station supplying the plant is evidently very far away, as there is a rotary converter and a step-up static transformer for furnishing power to it. The induced draft apparatus is housed in a small wing, and there is a second one covering the coal-receiving hopper, a rather unusual arrangement, as the majority of our railway shop power plants are simple rectangles in ground plan outline;

the breeching or smoke flue is of brick, a much better permanent arrangement than the usual sheet iron construction, which is liable to corrosion and is apt to cause interruptions of boiler service when renewals are required.

At Wilmington, Del., the power plant of the new P. R. R. shops also has interesting features; a track runs into the boiler room, but at trestle height above the floor; the coal is dumped on the floor and the boilers are hand fired; this arrangement of internal trestle is simple and direct, but is seldom used in the ordinary form of power plant, where the engine room and boiler room are side by side, as it would require the width of the building to be increased; but at Wilmington the two are end to end, and the width of the building was fixed by the engine room requirements, so that the internal boiler room trestle could be used to advantage, and without extra cost of building. In this plant the primary generators are alternating, although there is a secondary direct current generator, in addition to an exciter set; there being also a motor generator, a very flexible arrangement results, as, even with the complete disablement of either class of generating machinery, it will still be possible to produce either or both currents in limited quantity. Three separate switchboards are installed, one for local alternating current, one for local direct current, and one for direct current used in the signaling system of the main tracks. The air compressing plant is usually complete, as it supplies air not only for local use at the shops, but for the electro-pneumatic switch and signal system, as well; there are special after coolers, both air and water, designed by the railroad company and intended to condense and precipitate the greatest possible proportion of the suspended moisture, which is sure to cause trouble if allowed to pass into the service pipes, particularly those of the signal system.

Danville, Ill., on the C. & E. I., affords another example of recent power plant practice; here, on account of coal being cheap and water comparatively dear, compound cylinders and condensers were eliminated, and only simple engines are found; moreover, so much confidence is felt in the generating apparatus that no spare units are provided, although the power actually installed is in two units; direct current is used throughout, power being distributed on the two-wire system and lighting current on the three-wire. Here is also found the only known extensive application (in railway shop power plant practice) of the double commutator system of motor speed control; those motors which are to be worked at variable speeds have two distinct armature windings, each connected to its own commutator, and obviously these windings can be so proportioned as to give any desired speed ratios (within limits) when used either one singly, the other singly, or the two together. In practice these combinations are effected through a controller which may be placed conveniently to the tool operator, and which is arranged to switch in and out such varying amounts of field resistance as may be required to secure the necessary intermediate steps of motor speed. In this particular application each controller is also

equipped with automatic cut-outs for overloads and no load, so that the motor mechanism is well protected; it is quite possible that this and perhaps other installations of the double commutator system of motor speed control may make it necessary to revise the opinion previously expressed that the system was too complicated.

The Storehouse.— It is stated that the new storehouse of the Seaboard Air Line, at Portsmouth, Va., is one of the largest in the South; it is 70 by 225 feet and two stories; it has ample platforms, which are supported by earth filling, now planked over, but later, when renewal is necessary, to be cemented; the walls up to the level of the first floor window sills are of brick, but above that are corrugated galvanized iron on wooden framing; the roof is gravel; the whole making a very satisfactory, and also a very cheap, building.

At Wilmington the storehouse and office are combined, but at Danville they are separate.

The Layout.— A comparison of the layouts at Wilmington and Danville is instructive. At Wilmington the shop buildings are grouped as a unit or complete plant, while the roundhouse is isolated, being perhaps 1,200 feet (on the average) from the departments with which it has intimate relations, as, for instance, the storehouse, erecting, machine, boiler and smith shops; the roundhouse has a few machine tools as an offset to this. At Danville, on the other hand, the roundhouse is the center of the group, the other departments (above listed) being ranged approximately in a circle about, and equidistant from it; the car shop buildings, the power plant and the planing mill being given locations farther away.

General.— It is noticed that shop buildings are sometimes figured to even feet in their outside dimensions, and sometimes to even feet in their inside dimensions, in which latter case the outside dimensions will almost always involve inches, and in many cases fractions of inches. As a problem of shop design always begins with the layout, and as the ground areas covered by the several buildings are essential factors in the problem all through, there is every reason why even feet outside dimensions should be used; when the cross-sections are taken up it is just as convenient to start with an even outside as with an even inside span; in some cases neither the outside nor the inside dimensions can be expressed without resort to inches and fractions, and it is probable that in such cases the structural engineer has taken even feet for his roof span, making all other principal dimensions come out uneven. But this is a final plea for the uniform use of even feet outside dimensions.

MR. C. A. SELEY: I would like on behalf of the committee to express our appreciation of the assistance of Mr. G. M. Basford in editing the Soule articles, which are made a portion of this report.

THE PRESIDENT: The report is now open for discussion.

MR. F. F. GAINES (P. & R. R. R.): The report of the committee itself, I think, is as full and complete as it is possible to make on the subject in hand. They emphasize very clearly the impossibility of making any uniform recommendation that will cover different localities. The report, however, seems to question very strongly the advisability of large shops or the use of a single shop for a railroad system. The large shop is no innovation whatever. The Pennsylvania Railroad shop at Altoona, which has been in existence for a great number of years, is a fair example of large shops. The present output of our Reading shops, where all the heavy repair work for the road is done, has been brought up in the past year to an average of three engines per day, and will be a little over eight hundred engines for the year, an increase of twenty-two per cent over the previous year, and this has been done with a notoriously old tool equipment, and only a sufficient number of tools to operate forty-eight out of sixty-eight pits; in other words, the erecting shops, which are in two bays, have been divided into twelve pits to each corner, which are being operated, and the remaining pits used for storage purposes on account of lack of sufficient machinery to run them. On the basis of forty-eight pits we are getting about an engine and a half per pit per month.

Referring to the articles from the *American Engineer,* which are published as an appendix to the committee's report, there is considerable exception to be taken to them. Tables of outputs, such as are shown on page 16, are valueless unless considerably more is known about the conditions under which the output is made.

The character of traffic, grade, ballast, curvature, water supply, weight of engine, etc., varies for each locality. For instance, on a recent trip of inspection by some prominent officials, a certain shop located in a territory with a good water supply was very highly commended for its output on the unit basis. The average cost of engines repaired, however, was only from $300 to $350 per engine, or about one-fourth cost per engine at our Reading shops. During the past year the average cost of engines receiving general repairs was slightly under $1,500. This may seem high, but the power had become run down considerably, and the majority of

engines required heavy boiler work, so that while apparently high it is really a reasonably low figure, it being about the same as that for the Central Railroad of New Jersey, as the average cost per engine varies only a few dollars from the average cost per engine on the latter road. This shows the fallacy of comparing output of shops in different localities on the unit basis.

The proper proportion of floor area for each department, based on the number of stalls, is also worthless when simply tabulated without reference to conditions. A majority of the shop layouts are deficient in floor area for machine tools and boiler work. The newer heavier power requires much more machinery to obtain the same output as was previously accomplished when engines were small. Higher steam pressures have very noticeably decreased the life of flues and fire boxes, and many recently built shops are preparing to overcome this defect by extensions. As being of interest in this connection I have tabulated the present area and the area that will exist when the present extensions, which are now under way, are completed at our Reading shops:

SHOP.	Original area. Square feet.	Additional area. Square feet.	Total area. Square feet.	Area per pit as revised.
Erecting, 68 pits, two bays 740 x 70	103,600	.....	103,600	1,523 5
Machine, one bay, 740 x 60	44,400	Extension, 400 x 250 100,000	144,400	2,123 5
Boiler, 2 bays, 400 x 120	48,000	Extension, 220 x 170 / 400 x 50 \ 57,400	105,400	1,550 0

Referring to the table on page 15 of report comparing longitudinal and transverse shops, the first item should be stricken out from general consideration, as it applies only to localities where the ground space is limited and governs the design rather than the general utility of the design itself.

Item 2. From data on pages 11, 12 and 13 it will be seen that the width of bay necessary with either class averages nearly the same, being 65½ feet for the longitudinal, 68 feet for the transverse with cranes on one level, and 63¼ feet for transverse with cranes on two levels.

Item 3. Admits desirability of transverse arrangement.

Item 4. Admits desirability of transverse arrangement.

Item 5. Admits desirability of transverse arrangement.

Item 6. Lifting engines: Unless at all times the middle track of transverse shop is kept open, or sufficient space between the tracks is left for standing an engine, it will be necessary to lift the engines over other engines, either to bring them in or take them out. If the middle track is kept open or space between the tracks is allowed it becomes a very uneconomical distribution of floor space. I therefore fail to see any argument under this item in favor of longitudinal shops. On the other hand, granting it takes more time to lift engines in a transverse shop, which is questionable, the amount of such time is small and affects only a very small percentage of your force.

Item 7. For the same reasons as given under Item 6, it is questionable if it is any ways at all favorable to a longitudinal shop.

Item 8. If the work is handled properly there is absolutely no difference in either system, in either time or manual labor.

I have added Item 8¼, which is omitted and covers the distribution of material, access to machines and movement of men to and from toolroom, and is very decidedly in favor of the transverse arrangement.

Item 8½, also not given, covers the storage of wheels, handling and storage of locomotive parts during repairs, the transverse shop affording a much more flexible arrangement, as well as keeping the shop looking much neater.

Item 9 being a summary of various points for and against the two systems of shops would then appear as follows:

With Items 1, 2, 6, 7 and 8 equally favorable, and Items 3, 4, 5, 8¼ and 8½ in favor of the transverse arrangement, it would appear that the transverse arrangement is decidedly the best arrangement.

In a great many cases the blacksmith shop is used for both car and locomotive forgings. The use of steel castings for many locomotive parts, instead of forgings, and the manufacturing of other parts on turret lathes and special machines for bar stock, has greatly reduced the necessary output of this department, so

that while the Reading shop, having an area of 37,360 square feet, or 525 square feet per locomotive pit, is apparently small, it has been found from actual experience to be ample and with a good margin of reserve.

A sufficient number of cranes to properly handle the work should not be overlooked. In the older shops, which were not equipped with overhead cranes, each machine handling work of any size was provided with an air hoist or other lifting device for handling the material from the floor to machine and back again. In the newer shops, with the overhead crane service, the air hoist is practically eliminated, while a very small number of cranes has to do the work formerly done by a large number of air hoists or other similar contrivances. Before the advent of overhead cranes in locomotive shops a large portion of the moving and lifting was done by hand, but since the advent of cranes no one ever thinks of doing any such work, no matter how long he may have to wait for a crane. It therefore becomes doubly important to have a very large number of cranes serving each department, and it is also desirable, in addition to overhead crane service, at particular machines to install small independent hoists, either air or electric, where there is frequent need of such service.

With the installation of new cranes that are to be put in the present shops and the present extensions that are under way the Reading shops will have the following crane equipment: In each erecting bay one 120-ton, with two trolleys; one 35-ton, with two trolleys; two 10-ton, with single trolley. The main machine shop will have three 10-ton single trolley cranes. The covered storage yard will have one 10-ton single trolley and one 10-ton double trolley. The boiler shop, with two bays, will have in the main bay one 35-ton crane, with two trolleys, and one 10-ton crane, with single trolley. In the other bay three 7½-ton cranes, single trolley. In the machine shop extension the center bay has one 35-ton crane, with two trolleys, and one 10-ton single trolley. One side bay has two 7½-ton cranes, single trolley; the other side bay two 10-ton cranes, single trolley.

The cranes operating in one bay of erecting shop, center bay of machine shop extension and the main bay of boiler shop are all on the one runway, and are not absolutely confined to territory

designated. Those nearest the dividing line of each shop can be used when occasion demands in the next shop.

PROF. H. WADE HIBBARD (Cornell University): It seems to me that the happiest portion of this paper is that portion which the committee evidently desired this Association should recognize as important portions of the paper, namely the first portion — the first three or four pages relating to the men. I think we can judge of the proper conditions in railroad shops by fully appreciating what the committee has said with regard to the men to manage the shop, the heads and subordinates, all the way down, also including the individual workmen.

I have been very much interested this spring in talking with Mr. Vauclain and Mr. Johnson, of the Baldwin Locomotive Works, with regard to their shop organization. It is a fact, which I presume is well known to most of us, that they make a particular point in their shops of training up the younger men; and I would hope that the members of this Association in considering this paper and its discussion will group with it the discussions yesterday upon Mr. Basford's admirable paper. At the Baldwin Locomotive Works they have, for example, a superintendent of apprentices. Most of us know him, Mr. N. W. Sample. They do not let any question go by default, but have that man of wide experience in motive power work on our roads, and a man who loves the younger generation, to pay particular attention to the bringing up of the younger men, who by and by, and some of them already, are becoming subordinate officials of that plant. They told me there that they did not wish to take any man into their shops who should not have the privilege and opportunity of rising to the very top position. Mr. Johnson himself, in his line of work, the financial side of that plant, rose from being an ordinary clerk. I think most of us know from what position Mr. Vauclain rose, when he was a small man with the Pennsylvania Railroad; any man who goes into the Baldwin Works as an apprentice fully recognizes that it lies solely with each man himself whether or not he may become one of the firm. The positions in the firm of the Baldwin Locomotive Works, that is the old-fashioned close partnership, are not sold to any one; they are a

gift, a free gift to the man who can rise to the point where he is qualified to accept such a gift.

They take three classes of apprentices into their works. The ordinary apprentice, who has the ordinary common school or no education, is Class A apprentice; they take in the graduate from the high school and call him a Class B apprentice, and they take in the graduate from the engineering school — they do not call him a special apprentice, not by a long ways, but call him a Class C apprentice. Each one of these apprentices has a certain course laid out for him, a shorter course for the man who has already obtained a broader education than the other man, but they look out for the other man and see that he is properly educated. In some instances the advancement of these men is quite rapid. I know of men in these works who are now in charge of important departments, who have been there only two or three years, perhaps.

I am glad indeed that this committee has emphasized this side of the shop question, the shop layout if you please, the men to manage it, and the other points referred to here with regard to the men owning their own homes, school and church facilities, and things of that sort, so as to make the shop force a permanent rather than a floating population. It seems to me that the committee emphasizes that this is the main question as well as the shop question.

MR. A. E. MANCHESTER (C. M. & St. P. Ry.): I think the committee was wise in not laying down any plan or general layout for the locomotive shop. As has been referred to in the report railroad shops are frequently built to suit the ground, but were that not true, the policy and methods employed by the different shops are so vastly different, the various railroads are so vastly different, that it would not be practicable to give any fixed methods of procedure. For example, the question of whether the locomotive and car departments shall be together and under one general management, whether the railroad is practically a manufacturing establishment as well as a railway shop, whether they manufacture largely for their road departments and their bridge and building departments or confine their work almost exclusively to locomotive and car repairs or construction. Such a variety of

conditions come into the subject that I feel that the committee took the wise course in not recommending.

The question that we are all up against, perhaps, hard, is the one of results. The financial end of our railroads does not care so much upon just what line or method we proceed as what are the results, how much and how cheap and what the quality of the goods is that are delivered. This depends on a variety of conditions. A poorly equipped shop, well managed, and supplied or manned by workmen who are permanent, who own their homes, who live in the locality, who are desirous of continuing for a lifetime their service in that shop, will give better results frequently with poorer facilities than can be had with first-class facilities, but a transient lot of workmen. The putting of the work up to the men is another very important factor in a shop organization. In manufacturing establishments the way they get results is to keep a man on one piece or one class of work constantly. They have special tools for turning out this special work, and with all the jigs, templates, etc., that will facilitate the work, while it is not uncommon in a railway shop to see a man changing from one class of work to another several times a day. It makes no difference how good the workman is, if he has the work put up to him in this shape, it makes no difference how good a tool he has, the fact of the matter is the better the tool the more frequently he has to make the change, the worse he is off, because the excellent tool, the one that can possibly turn out work in duplicate in large quantities, takes a good while to make a change to another size or another class of work. I believe any observing man can go through almost any shop in this country and find some very good things being done in that shop, possibly some poor ones.

An important question in connection with shop arrangements is the selection of tools. Three years ago I had occasion to purchase quite a number of tools, and there were some of them that I was not personally well qualified to judge of, not having had personal experience with them. I sent out some experts to look for information in that direction, and I naturally directed them toward several new shops, that is, shops that had been in operation as new shops from one to two years. Among the tools that I refer to was a hydraulic plant with a riveting arrangement in a

boiler plant. The report that I received from one shop that had been in operation for two years was that they had a hydraulic plant of a certain make, it was installed in the shop in such and such a manner, and appeared to be a very well arranged plant and tools, but they were unfortunate in getting any information as to what the tools could do, or would do, if in actual operation, as the plant had been "in use only two years and they had not used it yet."

We can not help but admire the rapidity with which work is turned out in the large manufacturing establishments, and especially in the locomotive building shops, and I fear that sometimes, as we go through those large shops, and see the amount of work they turn out, we feel immediately that we should have some of those very tools, because we would like to see work turned out with that same rapidity from our shops; but the question is, would we be doing justice to our companies if we were to purchase that class of tools for our shops? I think not. I remember about four or five years ago I was looking for a tire lathe. I wanted something different, something better than was on the market at that time. I went to one of the large tool manufacturing establishments and gave them an idea of what I had in mind and asked them what they would do for me on that line. They immediately brought out their sales book and pointed out to me that within the last six months they had sold to the locomotive builders, referring along down the line, so many lathes of this size, and weight and power, and they thought that that would be just exactly the tool I wanted because it was entirely satisfactory, they understood, to the manufacturer. I know this is one of the things in which the manufacturer is not a leader. The road with which I am connected turns off more metal, does more actual work in turning tire every year than all of the locomotive shops in the United States combined. Therefore we should be the leaders, we should set the example of what is wanted in locomotive tire turning. After considerable efforts and working back and forth with the manufacturer over a period of six months, I finally got them started on a lathe that suited my ideas, and I have it in service and it is very satisfactory.

MR. C. A. SELEY (C. R. I. & P. Ry.): Mr. President, I would

just like to say a word in reference to the remarks of the first speaker. I congratulate the Reading Road on their ability to turn out engines with poor machinery, and am sorry if they felt an application of one of the hypothetical cases stated in the paper. I entirely agree with his contentions also that a comparison of roads in regard to turning out of repair work is impossible, as is also a comparison of tonnage ratings or anything else, where there is such a difference in the conditions.

In connection with longitudinal versus transverse track arrangement, I would have to consider the matter before making a definite reply to all of the criticisms in table 6, page 15. Personally I might say that my earlier life was spent, in the West, in transverse track shops. I did not know anything about the other. I thought the transverse track was it. But after three years of very happy experience with a longitudinal shop built back in the eighties, I was converted to a considerable extent by the remarkable production of repaired engines at the Roanoke shops of the Norfolk & Western Ry. In this connection I might say that I am not a transverse track man or a longitudinal man exactly, as may be noticed by the published description of the shop at Moline on the Rock Island, which has proved very successful in the handling of engines, taking them into and discharging them from the shop on the longitudinal plan, it is true, but holding them in the shop for their repairs on diagonal tracks, the purpose of the diagonal being to facilitate as far as possible cross communication from the engines to the departments on either side.

As has been stated by one speaker, the matter of personnel is considered the important portion of the paper, and I think that the paper presented by Mr. Basford yesterday covers some of the needs suggested in our report which was written prior to knowing what Mr. Basford was going to do in that respect. (On motion, the discussion was closed.)

THE PRESIDENT: If there is no objection, we will take up the report of the Committee on Locomotive Front Ends, of which committee Mr. H. H. Vaughan is Chairman. The report is as follows:

REPORT OF COMMITTEE ON LOCOMOTIVE FRONT ENDS.

To the Members:

Your committee on Locomotive Front Ends begs to state that at the last convention of this Association, a motion was carried authorizing the Executive Committee to appropriate, at its discretion, such funds as were necessary to carry out the series of experiments outlined in the report of this committee which was then presented, when money for such work should be available. It was then supposed that it would be necessary to await the receipt of funds raised by the subscription then contemplated for representative membership, but at a meeting of the Executive Committee held subsequent to the convention, the Secretary was instructed to issue a circular letter to the various railroad companies and locomotive builders in the United States asking for subscriptions to enable the *American Engineer* tests on locomotive front ends to be carried out to a conclusion. The responses to this letter were generous and immediate, and a total amount of $3,035 was contributed by the following railroad companies and locomotive builders:

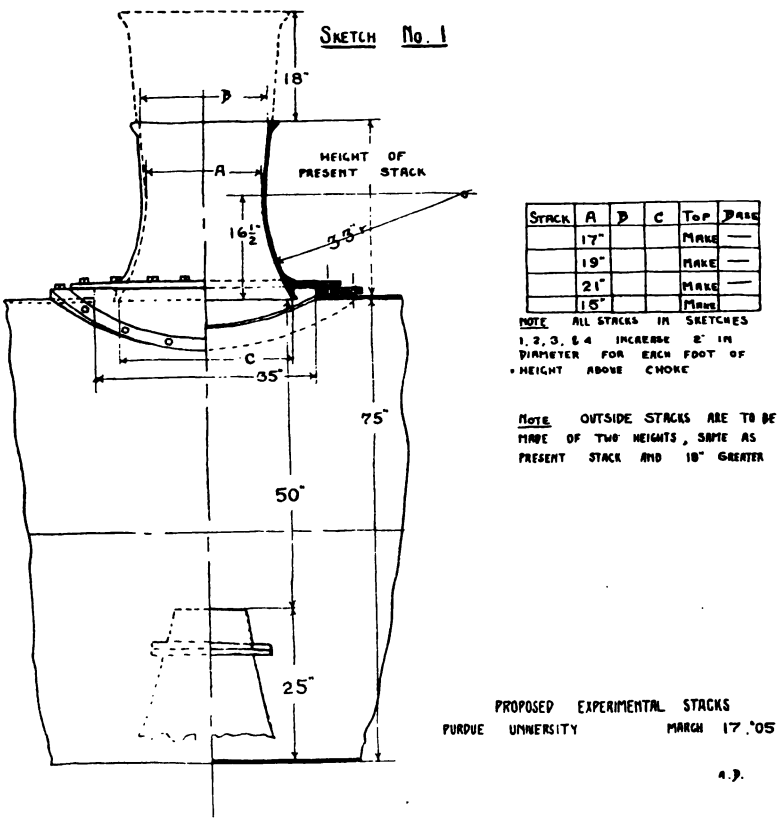
American Locomotive Co.	$ 215.00
Ann Arbor R. R.	10.00
Baldwin Locomotive Works	215.00
Buffalo, Rochester & Pittsburgh Ry.	20.00
Bessemer & Lake Erie R. R.	10.00
Canadian Northern Ry.	10.00
Chicago & Western Indiana R. R.	10.00
Chicago, Lake Shore & Eastern Ry.	5.00
Colorado Midland Ry.	10.00
Canadian Pacific Ry.	90.00
Cincinnati, Hamilton & Dayton Ry.	10.00
C. H. Cory	10.00
Chicago, Burlington & Quincy Ry. (West)	40.00
Chicago, Burlington & Quincy Ry. (East)	80.00
Chicago & North-Western Ry.	130.00
Chicago & Eastern Illinois R. R.	20.00
Cincinnati Northern Ry.	10.00
Cincinnati, New Orleans & Texas Pacific Ry.	10.00
Central New England Ry.	10.00
Chicago, Indianapolis & Louisville Ry.	10.00
Cleveland, Cincinnati, Chicago & St. Louis Ry.	50.00
Chicago, Milwaukee & St. Paul Ry.	100.00
Cumberland Valley R. R.	10.00
Chicago Great Western Ry.	30.00
Chicago, Rock Island & Pacific Ry.	116.00
Chicago & Alton Ry.	20.00
Duluth, Missabe & Northern Ry.	10.00
Delaware, Lackawanna & Western Ry.	60.00
Duluth, South Shore & Atlantic Ry.	10.00
Duluth & Iron Range Railroad	10.00
Delaware & Hudson Co.	30.00
Elgin, Joliet & Eastern Ry.	5.00
Erie Railroad	25.00
Grand Rapids & Indiana R. R.	10.00

Great Northern Ry.	$ 70.00
Galveston, Harrisburg & San Antonio Ry.	30.00
Illinois Central Railroad.	110.00
International & Great Northern Ry.	10.00
Intercolonial Railway	20.00
Kansas City Southern Ry.	10.00
Long Island Railroad.	25.00
Lake Shore & Michigan Southern Ry.	50.00
Louisville & Nashville R. R.	50.00
Michigan Central R. R.	40.00
Maine Central R. R.	10.00
Minneapolis, St. Paul & Sault Ste. Marie Ry.	10.00
Mobile & Ohio R. R.	10.00
New York, New Haven & Hartford R. R.	25.00
New York, Ontario & Western Ry.	10.00
New York, Chicago & St. Louis R. R.	10.00
Nashville, Chattanooga & St. Louis R. R.	20.00
Norfolk & Western Ry.	60.00
Northern Pacific Ry.	90.00
Oregon Short Line.	10.00
Oregon Railroad & Navigation Co.	10.00
Pennsylvania Railroad	300.00
Penna. Lines West.	120.00
Pittsburgh & Lake Erie R. R.	10.00
Pere Marquette R. R.	30.00
Richmond, Fredericksburg & Potomac Ry.	10.00
Southern Ry.	110.00
St. Louis & San Francisco R. R.	70.00
San Pedro, Los Angeles & Salt Lake R. R.	10.00
Seaboard Air Line Ry.	30.00
Southern Indiana Ry.	10.00
San Antonio & Aransas Pass Ry.	10.00
Southern Pacific Company.	90.00
Texas & Pacific Ry.	30.00
Toronto, Hamilton & Buffalo Ry.	10.00
Terre Haute & Indianapolis R. R.	10.00
Union Pacific R. R.	50.00
Virginia & South-Western Ry.	10.00
Wisconsin Central Ry.	10.00
Western Ry. of Alabama.	10.00
Wheeling & Lake Erie Ry.	10.00
Wabash R. R.	40.00
Total	$3,065.00

Your committee was thus furnished with the necessary funds to carry out the work assigned to it, but unfortunately the testing plant at Purdue University was then occupied with other experiments and could not be released for the purpose of carrying out the tests on locomotive front ends. These experiments have not yet been concluded, but we are pleased to advise that arrangements have been made whereby the New York Central has kindly offered to loan us a locomotive by October 15 of the present year, at which time Purdue University will make arrangements to receive it. The tests that it is proposed to make have been modified somewhat from the outline given in 1904 report, and your committee begs to present

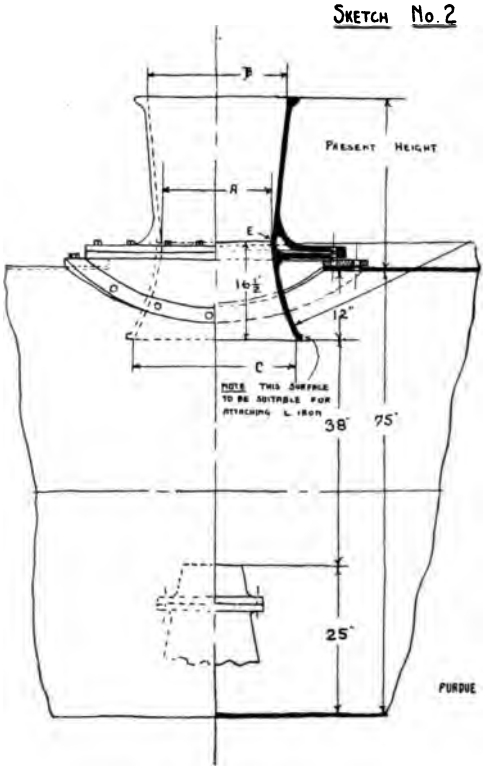
the following scheme of experiments for the criticisms of this Association, which will, of course, be carried out on a New York Central engine having large front end diameter, which will decide the relations between large and small front ends:

1. Diameter of Stack.— It is proposed to conduct tests involving four different diameters and two different heights of outside stacks of dimensions set forth by Sketch 1, the lower stack to have a height normal to

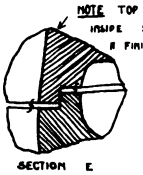

SKETCH No. 1
18"
D
A
HEIGHT OF PRESENT STACK
16½"
C
35"
75"
50"
25"
STACK | A | D | C | TOP | BASE
17" | MAKE | —
19" | MAKE | —
21" | MAKE | —
15" | MAKE
NOTE ALL STACKS IN SKETCHES 1, 2, 3, & 4 INCREASE 2" IN DIAMETER FOR EACH FOOT OF HEIGHT ABOVE CHOKE
NOTE OUTSIDE STACKS ARE TO BE MADE OF TWO HEIGHTS, SAME AS PRESENT STACK AND 18" GREATER
PROPOSED EXPERIMENTAL STACKS
PURDUE UNIVERSITY MARCH 17 '05
A.J.

the engine, the higher to have a height 18 inches greater than this. The diameters to be 15, 17, 19 and 21 inches respectively. It is expected that data thus derived from a boiler of large diameter will serve in checking formulæ based upon results obtained from the small boiler of the Purdue locomotive, or in case they do not check, it will serve in the establishment of new formulæ. All stacks of whatever diameter or height, are similar in form. The curvature of the base is the same for all and the distance

Sketch No. 2



Stack	A	B	C	Top	Base
	17"			Make	Make
	19"			Make	Make
	21"			Make	Make
	15"			Make	Make



Note Top and base of all inside stacks must have a finished joint at E.

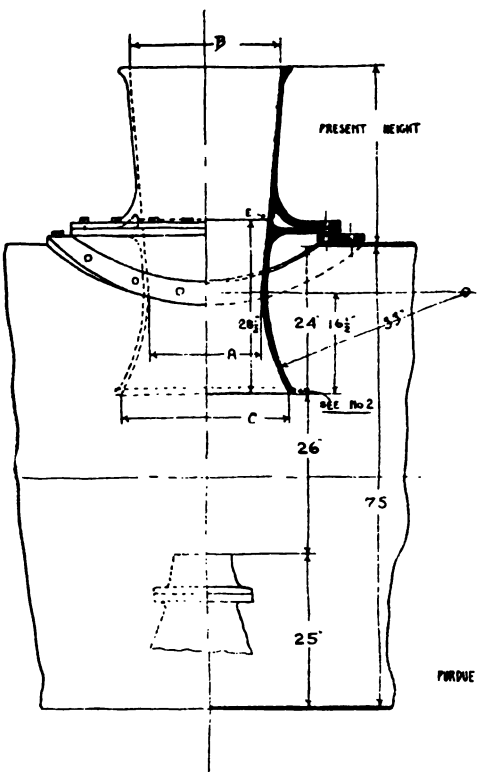
Section E

Proposed Experimental Stacks

Purdue University March 17, '05

A.P.

Sketch No. 3.



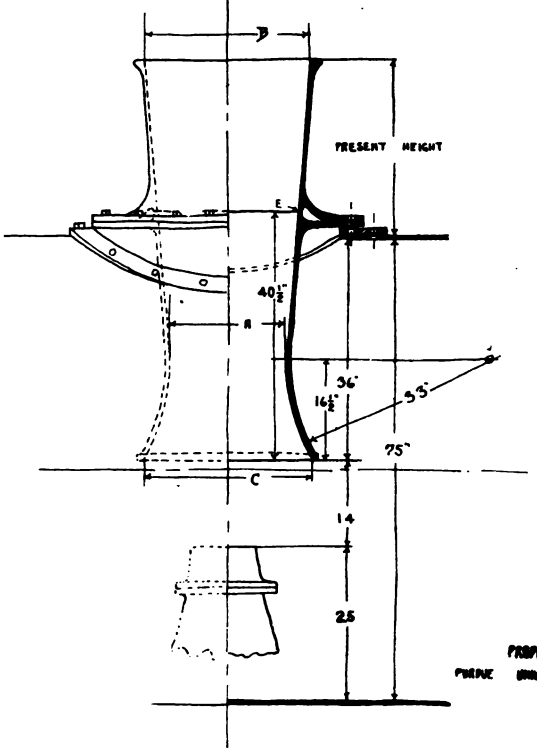
Stack	A	B	C	Top	Base
	17			-	Plate
	19"			-	Plate
	21'			Plate	Plate
	15"				Plate

NOTE FOR DETAIL OF FINISHED JOINT AT E SEE SKETCH No 2

PROPOSED EXPERIMENTAL STACKS
PURDUE UNIVERSITY MARCH 18, '05

A J

SKETCH No. 4



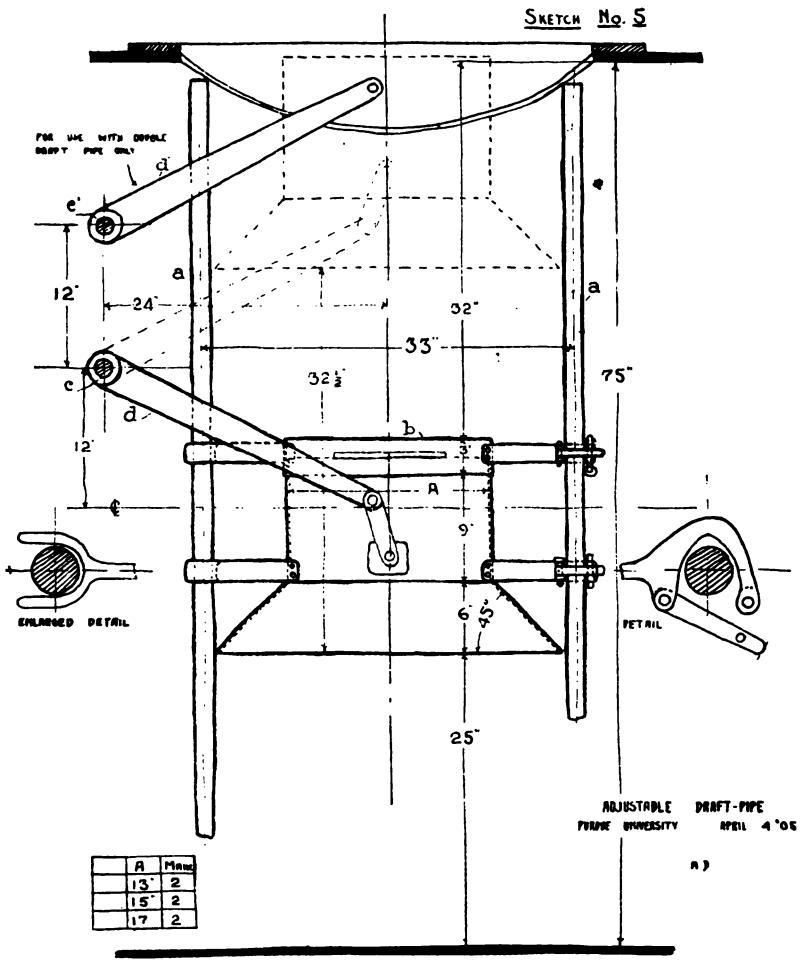
STACK	A	B	C	TOP	BASE
	17"	"		-	MAKE
	19"	"		-	MAKE
	21"		-	MAKE	MAKE
	15"	-	-	-	MAKE

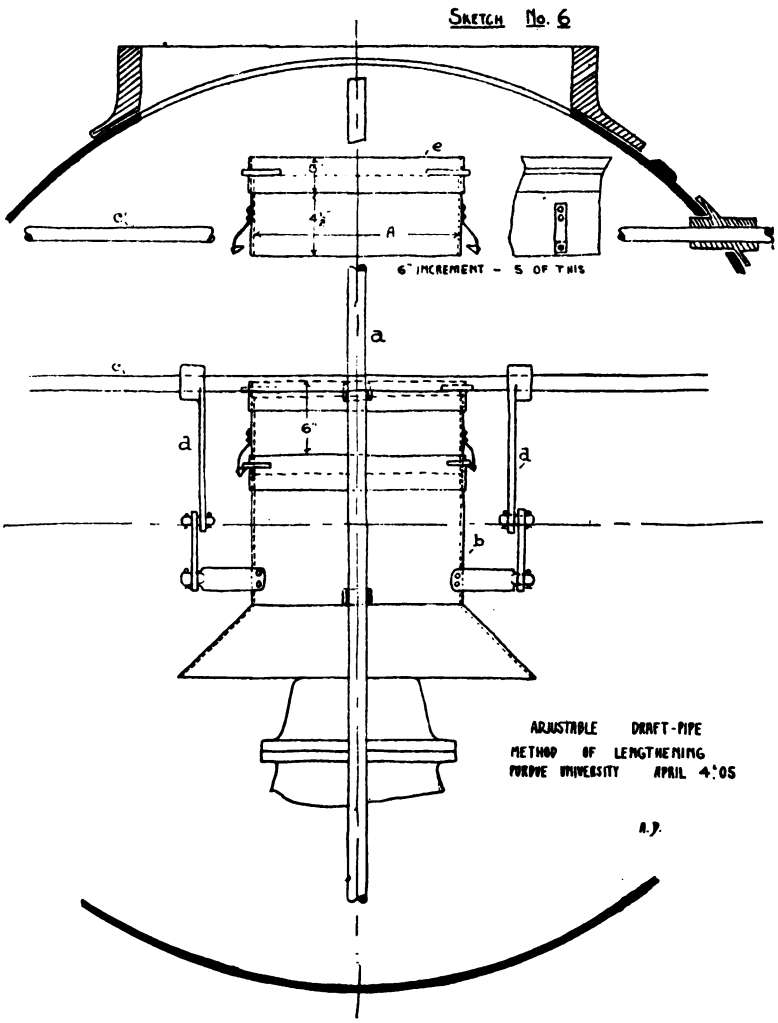
NOTE. FOR DETAIL OF FINISHED JOINT AT E SEE SKETCH 2.

PROPOSED EXPERIMENTAL STACKS

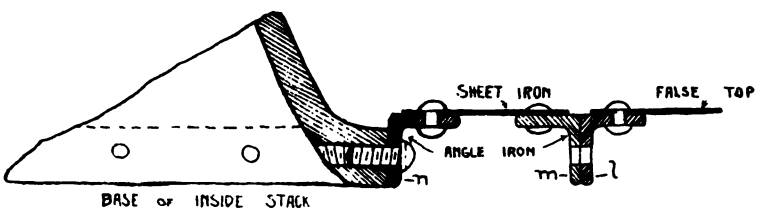
PURDUE UNIVERSITY MARCH 18 '05

A.D.


SKETCH No. 5
FOR USE WITH DOUBLE DRAFT PIPE ONLY
d'
e'
12"
24"
a
32"
33"
32½"
75"
c
d
12"
b
3"
A
9"
6"
45°
25"
ENLARGED DETAIL
DETAIL
ADJUSTABLE DRAFT-PIPE
PURDUE UNIVERSITY APRIL 4 '05
A)
A
Marks
13"
2
15"
2
17
2


SKETCH No. 6
e
c
4½"
A
6" INCREMENT - 5 OF THIS
a
c
a
6"
a
b
ADJUSTABLE DRAFT-PIPE
METHOD OF LENGTHENING
PURDUE UNIVERSITY APRIL 4'05
A.J.

Sketch No. 7



PROPOSED EXPERIMENTAL STACKS
METHOD OF BLANKING TOP OF SMOKE BOX
PURPOSE UNIVERSITY MARCH 23, 05

A. P.

from the lower end to the point of greatest contraction is the same. Above the point of greatest contraction, all have a uniform taper of 2 inches to the foot.

2. INSIDE STACKS.—To determine the value of the inside stack, it is proposed to employ four different diameters and three different lengths, all to be used in connection with an outside stack of height normal to the engine. The proposed stacks are shown by Sketches 2, 3 and 4. As in the case of the outside stacks, the inside stacks are similar in form, all being the same in the curvature of their base, the distance from the point of greatest contraction to base, and in the degree of taper of the upper portion of the stack.

3. FALSE TOPS.— For the purpose of determining the effect of blanking off the top of the smoke box, it is proposed to construct a false top which may be used in connection with stacks having 12 and 24 inch inside projection (Sketches 2 and 3). Each top will have in the center a circular opening reinforced by an angle iron (L), this opening to be sufficiently large to admit stacks of the largest diameter. To make connection with the stacks of different diameters, filling rings will be employed, made up of two angles and a sheet-iron plate, as shown at M, N, Sketch 7.

4. DRAFT PIPES.— It is proposed to employ single-draft pipes having diameters 13, 15 and 17 inches and lengths from 18 inches to 48 inches, lengths to increase by 6-inch increments. Each increment is secured by adding a new section, as shown by Sketch 6.

Experiments upon double-draft pipes will be made to involve the apparatus already outlined. To give facility in adjusting the draft pipes, it is proposed to have them so mounted that they may be raised or lowered by means of levers extending outside of the smoke box. The details of this arrangement are suggested by Sketches 5 and 6. By reference to these figures it will be seen that two columns (*a a*), having their support in an extension upon the exhaust pipe, are provided as guides for the draft pipes. The draft pipe *b* slides freely on these columns, being applied thereto by some form of fitting which will admit of easy adjustment. The vertical position of the draft pipe *b* is controlled by its connection with the lever arm *d* and the shaft *c*. The latter is supported by bearings attached to the smoke-box shell and extends out through the shell a sufficient distance to receive a counterweight and operating lever not shown in the drawings. By having the operating lever pass over a graduated scale, it is thought that it will be possible to place the draft pipes in definite positions without the necessity of opening the front door.

It will be seen that your committee is not carrying out the instructions under which it was appointed, so far as experimenting on the elimination of the diaphragm is concerned; this has been shown by the experiments on the testing plant at St. Louis to be a most important factor in the proportion which the draft utilized in burning coal bears to the total draft produced, but in view of the information that has been obtained on

this subject at St. Louis, your committee considers that further experiments on the testing plant would be valueless. Assuming that the first requirement is to obtain a self-cleaning front end, it will require lengthy and practical experimenting to ascertain what design will afford the self-cleaning feature with the least obstruction to the passage of the front end gases, and your committee feels that this subject will have to be determined by experimenting on engines in actual road service before any useful work in this connection can be done upon the testing plant.

As matters stand, therefore, your committee proposes to carry out the series of tests outlined above, and would recommend that, in order to furnish the members of this Association with the results of these tests prior to the next convention, it be empowered to publish them in the *American Engineer* as the tests are concluded, and asks to be continued in order to carry out the work assigned to it.

H. H. VAUGHAN, Chairman,
F. H. CLARK,
ROB'T QUAYLE,
A. W. GIBBS,
PROF. W. F. M. GOSS,
Committee.

MONTREAL, CAN., May 11, 1905.

MR. H. H. VAUGHAN (Can. Pac. Ry.): Mr. President and Gentlemen, the report on Locomotive Front Ends practically speaks for itself, and I think it is unnecessary to read it. This front end matter has been a very disappointing one for the committee concerned. We have been continually held up through, I really think, no fault of our own in carrying these tests to a conclusion, and this report really states that the most important part of their work in this connection has been accomplished, namely, the raising of the money. The rest I think will be comparatively easy. The responses to the circular letter were most gratifying. In fact, the railroads were certainly generous in their contributions, and as a consequence it has been decided that in place of getting one or two roads to carry the largest part of the burden, as we had anticipated, that all the expenses in connection with the tests for apparatus and so on will be taken out of the fund subscribed. We have shown the apparatus it is proposed to use and which has been designed by Professor Goss and Mr. Whyte, and I would say that while this subject seems to be everlasting, I now think there is a good reason for going ahead on the lines we had laid down and finishing up the experiments that will

determine the relation of the stack and nozzle. We have been told these experiments all lead to nothing, because we no sooner get out a relation than somebody finds he can improve on it on his own engines. At the same time the previous experiments carried out within the last couple of years have had quite an influence on the design of stacks and nozzles at any rate, by the locomotive builders, and with good results, and I think that without violating any confidence we can say that the tests at St. Louis have demonstrated some of the reasons for results being obtained that do not always appear in conformity with the experiments carried out by the front end committee. It has been found that one of the most important things in the drafting of the engines is the loss of draft in the gases passing by the diaphragm. The variation between different engines in that respect may be so serious as to overcome any increased efficiency in the stack arrangement of one engine over another. Now this committee has simply shelved that question. There is no reason why we should not carry out experiments on the diaphragm if the meeting desires it, but my feeling, and I think that of the other members of the committee, is that experiments on diaphragms can not be properly carried out in a testing plant. The whole diaphragm question to-day I think comes to the construction of a self-cleaning front end without too much obstruction to the draft. We have assumed in our committee meetings that a self-cleaning front end is a necessity in modern locomotive practice. If it is not, then we can probably make some experiments on the plant, but assuming that it is, we do not think that we could carry out experiments on the plant with reference to obtaining a self-cleaning front end as satisfactorily as they can be carried out on the road. So that all we can say is that from our knowledge of the results at St. Louis the most important question in connection with draft confronting the locomotive designers to-day is the obtaining of a self-cleaning front end that offers less resistance to the passage of the gases than the one that is in common use. In some cases half the total draft created was required to get the gases from one side of the diaphragm to the other. Now, when you come to think that we have been spending money and making experiments to see if we can not enlarge the nozzle a little bit and get a more

efficient stack, and then after obtaining the most efficient arrangement possible, with one and two and three petticoat pipes and one thing and another, we are losing all that by the faulty front end construction, it shows we have been really working at the wrong end of the problem. At the same time for accurate locomotive designing it is desirable and necessary to settle on the proper relations of stacks and nozzles, and the experiments outlined in this report will, I think, accomplish that.

MR. C. A. SELEY: I move that the report be received; also that the committee be continued to carry out its recommendations. Carried.

THE PRESIDENT: If anybody wishes to say anything regarding the report of the committee and the remarks of Mr. Vaughan, he is at perfect liberty to do so. If no member wishes to say anything, we will pass on to the next on the program.

THE SECRETARY: Mr. President, the next subject on the program is the discussion of an individual paper by Mr. C. B. Young, on "Proper Lubrication of Valves When Drifting," and also "Relative Setting for Piston and Slide Valves." After the program was printed I asked Mr. Young how soon he would have his paper into the office, and he said that he had not been able to do anything in regard to the matter at all, and asked that it be postponed or the subject dropped.

I would suggest, Mr. President, before we go to the discussion of topical subjects, that we take up the two topical subjects that were left over from yesterday, the one on "High-Speed Steel" and the other on "Mechanical Stokers."

THE PRESIDENT: If that is the pleasure of the convention we will do so, and will first consider the subject of "High-Speed Steel."

THE SECRETARY: Mr. Carney sends in the following:

HIGH-SPEED STEEL.

MR. J. A. CARNEY: The almost prohibitive cost of high-speed steel makes one consider carefully whether or not it should be purchased for all classes of work, and especially for old machines which can not tax the capacity of the cheaper self-hardening

steels. When one figures that a tire lathe tool costs from $8 to $10, it looks like a lot of money. On the other hand, if we will take into consideration the slower speed, smaller output, time lost sharpening and dressing tools and the loss of material incident to dressing and sharpening, it will be seen that the cheaper tempering and self-hardening steels are too expensive to be considered. A case in question: A set of bolt cutter dies made of 10-cent tempering steel costs 21 cents for labor and 5 cents for material, total 26 cents, and cut 100 bolts before dressing. A set of similar cutters made of 75-cent high-speed steel cost 37½ cents for material and 40 cents for labor, total cost 77½ cents, and cut 1,100 bolts before dressing. Enough tempering steel cutters to do the same work would have cost $2.86. This is what I mean when it is said we can not afford to use low-capacity steel.

The use of tool holders and smaller sizes of steel will effect great economies in the investment of high-speed steel, and in one instance the introduction of tool holders reduced the number of pounds of steel required for a wheel lathe over 80 per cent, and instead of a tool 1 by 2 inches, 18 inches long, costing $7.87, a 1 by 1 by 8 inch tool, costing $1.87, is used, and the tool holder does not wear out or break and costs 5 cents per pound, against 75 cents per pound for high-speed steel.

Rosebit reamers can be tipped with high-speed steel and increase their efficiency from 750 to 1,000 per cent; in fact, a little ingenuity and thought will open up economies in the quantity of high-speed steel that were never given a thought when 10-cent steel was used.

Larger section tools of high-speed steel which have become too short can be hammered out into tools of smaller section with excellent results.

High-speed steel has come to stay until some more efficient material is discovered, and while its price may make us question its economy, a second thought will convince us that we can not afford to go back to the cheaper tool steels for heavy work, however good these may be in their class.

THE PRESIDENT: Gentlemen, the individual paper has been read. If any one wishes to say anything on the subject we shall be glad to hear from him.

If nobody has anything to say we will pass on to the next, which is " Mechanical Stokers."

THE SECRETARY: Mr. Garstang, of the Big Four Road, was called upon to open the topical discussion on Mechanical Stokers and as he can not reach Manhattan Beach until to-morrow he has sent in the following discussion:

MECHANICAL STOKERS.

MR. WM. GARSTANG (C. C. C. & St. L. Ry.): Your assignment on the subject of automatic stokers has been accepted by the undersigned, more from a sense of duty than any other inclination I could imagine.

The question of a scientific method of firing locomotive engines is not of recent origin. It has always been uppermost in the minds of the management of railways, as is evidenced by the fact that some companies have offered prizes of various kinds for the most efficient and economical firing, and this, too, in the day of the small engine, whose grate area did not exceed 30 square feet, with a maximum steam pressure of 180 pounds. If it was a question then, how much more important it must be to-day with 50 square feet of grate area and a steam pressure of 200 pounds or more.

Two hundred pounds of coal is an enormous quantity to burn per square foot of grate in an hour, but it can be done, and this would mean, with a grate having 30 square feet of surface, the consumption of three tons an hour. This implies a shovel of coal every ten seconds, and we believe this is as much as the ordinary man can do. If we obtain, by compounding or superheating, more steam from three tons of coal, we have increased the capacity of the fireman, but who can say how long it will be before we must further increase the size of our engines and consequently the capacity of the fireman, the latter now admitted to be up to the limit.

Ten years ago the most of us thought the maximum size of locomotives had been reached, when a spurt followed and the locomotive grew rapidly. Has the limit yet been reached? The engine having grown to such proportions in the past ten years, it is pertinent to ask, has the fireman also grown in that time?

Experience says " No." An engine with 50 square feet of grate surface, burning 200 pounds per hour per square foot, will consume five tons per hour, and if you get a fireman with sufficient physical endurance to handle five tons of coal per hour on an engine scheduled 45 (or 50) miles per hour, as they are to-day, he will very likely fall below the requisite in brain power, and of course, be an inefficient fireman. This we all know from experience. So it seems our engines have passed the limit of human endurance in the matter of efficient firing.

A young man thinks he would like to fire a locomotive; he makes application for the job; he goes with the foreman to look over an engine, and the enormous size of the boiler fills him with dismay, and he goes into some other business. This means that the work on the big engines is more of brawn than of brain. Some will say " That is all you need for a fireman." But where are our engineers to come from? Surely they must be men of " head," now more than ever, when speeds are high and trains are heavy. This employment of " coal heavers " for the left-hand side of the engine will surely be felt before long on the right-hand side, when promotions must be made.

They say " Necessity is the mother of invention." It seems to have been so in this case. I presume some one, seeing farther ahead than most of us, thought, " Why won't an automatic stoker work as well on a locomotive as on a stationary boiler? " To think was to act, and we now have a practical mechanical fireman that is going to revolutionize the grade of men who enter the firing service and eventually become engineers. Instead of the " horny-handed son of toil," with a back like a horse, who must work like a coal heaver for ten or twelve hours continuously, we will have a set of men of greater intelligence — men whose heads will guide the stoker and control it — men who will not sit idly in the engine cab by any means, but who, though busy, will not be continually " frizzled " back of the open fire door, with their eyes blinded so that signals can not be properly interpreted; but who, through intelligent operation of the stoker and careful watchfulness of the track and signals, and who coming in from a trip are not so tired out that they can not study the rules and regulations and prepare themselves for advancement, will make a high grade

of locomotive engineers when advanced to that position, and which will gradually mean a continuous elevation of both the men and the service.

Now, as to the stoker in actual service. It has been four years since the first mechanical stoker was tested on a Big Four engine. About six months ago we installed a mechanical stoker known as the " Victor," and same as the one on exhibition at the convention, on seven of the largest passenger engines on our system. Four of these engines have wide fire boxes and three have the long, narrow fire box. Both styles of fire box have been fired satisfactorily by the Victor mechanical stoker. From advices we receive from the division officers, we can safely say there is a noticeable saving in the amount of coal consumed per car and engine mile when operated with the stoker in comparison with hand firing, but at this time we are not prepared to state the exact per cent of such saving. The same advices indicate a reduction of boiler work, on flues, stay bolts and fire box seams, which, in our opinion, is due to the fact that we are enabled to carry a lighter, cleaner and more uniform fire, as well as uniform boiler pressure.

During the six months in which these stokers have been in service the cost of their maintenance has been very light. The principal cost of maintenance is largely due to improper lubrication. What few failures we have had with the stoker are due to the same cause.

In conclusion, I will say it is my opinion the mechanical stoker for locomotives has come to stay.

First, because it is practical and efficient.

Second, we believe, by the adoption of the mechanical stoker the railway companies will be enabled to use a cheaper grade of coal than can be used in hand firing, resulting in a great reduction in their fuel bills.

Third, it will relieve the fireman of some of his most arduous labor and give him greater opportunity to observe signals while on duty, and he will arrive at the end of his run in condition to improve his chances by study for promotion to the position of engineer.

THE PRESIDENT: The subject is now open for discussion.

MR. E. W. PRATT (C. & N.-W.): At a discussion last winter at the Western Railway Club, when the subject of the apprenticeship of firemen was under way, one of the members remarked very tritely that it was the wooden end of the shovel that you should look to for the saving of coal. I hope that that statement can be changed, with the results of further experience with stokers, so that it will be equally true that it is the mechanical end of the fireman that will save the coal.

MR. GEORGE L. FOWLER: I had the pleasure a few weeks ago of taking a trip over Mr. Garstang's road on an engine equipped with one of the stokers of which he speaks. I have been very much interested in the matter for a number of years, and I was more than surprised at the results which were obtained on that line. We left Cincinnati on a train consisting of eight cars weighing approximately 440 tons, hauled by an Atlantic type engine. The stoker was in use all of the way. The coal was a very fine grade of West Virginia coal from the Kanawha mines. It was kept well wetted down and the work that the fireman did as far as coal shoveling was concerned was merely dumping the coal into the hopper and the stoker did the rest. After leaving Cincinnati about nineteen miles there is a very heavy grade, thirteen miles long, and rising at the rate of about fifty-five feet to the mile. We went up that grade in, I think, twenty-five or thirty minutes, with the pointer glued at about one hundred and ninety to one hundred and ninety-five pounds, and the fireman apparently taking it very easy. He would fill up the hopper and then hang around and fill it up again. He did not show any signs of fatigue. He did not perspire in the slightest and had ample time to stand in the gangway and get cool. The engine held its speed and steamed right up the grade.

After we passed over the summit of the grade we struck an undulating run and they had some trouble with the left-hand injector. The right-hand injector of the engine was not capable of supplying water enough to keep the boiler full and the engineer put on the left-hand one. It did not work well at first and he was delayed five minutes in getting it started, and in the meantime the stoker had been neglected. The steam dropped down to 160 pounds, but that did not seem to annoy the crew in the

slightest. The fireman filled up the stoker, adjusted the speed, and in ten minutes the pressure was back to 190 pounds. In the meantime the engine was running at the rate of fifty-five miles an hour. That may sound as if the stoker was the whole thing, but really the fireman is the whole thing. He was not working very hard physically, but he was manipulating the stoker every inch of the way. He stopped it between twenty-five and thirty times between Cincinnati and Indianapolis. He was constantly adjusting the speed — he was regulating it all the time in order to get the results, but he kept up steam with much less physical exertion than had be been shoveling coal. There was no fire blazing in his face. He was able to keep cool and comfortable all the time, as the fire door was not open, and the work went along easily; all the man had to use was his head. That was a case where the work was lowered very materially, and the fireman says himself that it is very much less work to take care of the engine with the stoker than it is without it. Judging from the general appearance of the tender when we got to Indianapolis I should say we had used from 3.5 to 4 tons of coal on the run, not very heavy work, but still a good big train.

The stoker is not yet, I think, in its finished condition; there are many little things about it which can be improved. It is by no means a smoke-consumer. The smoke is black from start to finish, there is no entire clearing up of it, still one can count the strokes of the stoker by the appearance of the stack. When the plunger draws back it opens a space about five or six inches in diameter and allows an inrush of fresh air. When that air comes in the smoke lightens up, and as the opening closes on the forward stroke of the plunger, shutting off the supply of air, the smoke becomes thicker and is very black, just as black as any smoke coming out of any stack would be. That means, of course, that some change in the admission of air above the fire may be an advantage. Then, too, the stoker labors under the disadvantage in these cases of being applied to an ordinary fire door. I think the fire door was only fifteen inches in diameter and with the stoker occupying the bottom and the slide at the top, there is but little space at the top of the doors, so that the man can see the fire. The fireman had to rake the fire twice in making the run, and

when the rake was down through the hole it was difficult to see the whole surface of the coal. He had to look in first and see what he had to do, and then do it. That is a matter which may be easily remedied by making a larger door, or a supplementary door. The coal had been broken up to small size lumps; but in case it is not so broken up — if a large piece gets in — the stoker goes forward and hits it and breaks it, and what it does not get the first time it gets the next. There is no trouble in that way at all; but this difficulty could be readily adjusted in the case of an engine that was built for the use of the stoker — not applied as it was there — and a very great improvement in coal consumption probably be made.

Mr. Garstang told me, and the men on the road seem to think as it stands now, that there is no perceptible saving in the amount of coal that is used over the other engines. It is running along practically the same, but the fact remains that the men all like the stoker, both the engineers and firemen. As the stoker is now arranged, it stands on three legs, wabbles a good deal because there is no means for fastening it, and it is not exactly what would be put up as a permanent construction, although it is arranged to be readily removed and gotten out of the way. The fireman of an engine I was riding on told me that he had a case of failure when he was operating the stoker; that something had broken, and he had the stoker out of the way and put back on one side in about ten minutes. The coal clogged a little at one point in the run. The stoker is arranged so that the top opens readily, and can turn back so as to allow the inside to be cleaned easily.

I think on this occasion he had the stoker shut down for about a minute and a half, in which time he cleaned the thing out thoroughly, put it back in position and started it working.

As far as that one trip is concerned the stoker seemed to be eminently successful and there was no preparation for the run at all. No one in connection with the stoker company or the mechanical department of the railroad company knew I was on that engine, until we reached the end of the run.

MR. W. E. SYMONS (K. C. So. Ry.): Mr. Garstang's very interesting paper on the stoker brought out many good points. I think this is a subject which should be taken up in regular com-

mittee work. Undoubtedly the Association will be called upon from time to time to note the progress made. The roads buying large power I think are contemplating the use of a mechanical device for firing their engines and it seems as reasonable to suppose that it will become a fixture on these large engines as that the injectors of to-day displaced the pumps used years ago.

I think this subject should be continued in regular committee order, by roads that have engines equipped, and other roads that are equipping their engines, conducting experimental work of this nature on engines of various sizes, particularly of large engines in different territories, where different grades of fuel are used, in order that the association may have the full benefit of the conclusions reached resulting from these investigations, covering a considerable territory and period of time.

MR. W. S. MORRIS: I heartily concur in Mr. Symons's remarks in suggesting that this subject be assigned to a special committee, which committee shall conduct tests and experiments and make an exhaustive report.

I can not help but refer also to Mr. Fowler's remarks, where he states that the stoker is eminently successful; but he reminded me somewhat in his description, of the hod carrier who carried the bricks to the top story of a building and the man there did the work. The fireman has to shovel all the coal into the hopper, and that is a feature I think must be overcome. He shovels from twelve to fourteen, or sixteen, possibly, tons of coal over a certain division in the case of a large engine, and that is almost the limit of physical endurance, so that in many cases it is necessary to supply relays of firemen to relieve the tired men.

I think the stoker has come to stay. I think in its present condition it is a wonderful addition to the service. We do not have the firemen to-day that we did ten years ago, even. There is no attraction for a young man to accept a position as fireman, as Mr. Garstang states. He comes up to the registering station and sizes up the engine, and if he is pretty gritty about one out of five will go part way, and that is about the end of it. The brakeman's position is more attractive, and we do find among the brakemen, particularly among the new men employed, a higher degree of intelligence, because the work is not so exhausting.

The firemen of to-day do not take the positions through choice; it is largely from necessity. The stoker even in its present state relieves to a great extent the work of the individual in that position.

Four or five years ago, when this stoker was first introduced, I had some experience with it and personally made several trips with the stoker on an engine having an 11-foot fire box, where it was not possible to keep the steam up to the popping point when the engine was fired by hand. The application of the stoker on the same engine kept the engine steaming to the point of blowing off up an 80-foot grade with full tonnage all the time.

Mr. Fowler states that there is a good deal of smoke. Now, while there may be some, I believe the constant introduction of coal in proper quantities had a great deal of effect on the amount of smoke emitted from the locomotive at the time I made the trip up the mountain on the C. & O. Road.

I therefore make a motion that a committee be appointed to take the locomotive stoker in hand and follow it. In other words, I would like to see a standing committee on that subject, because I think it is a progressive measure and one upon which we are all anxious to get the fullest information.

MR. ANGUS SINCLAIR: I have had considerable experience with the automatic stoker in watching its operation while riding on engines equipped with it, and I wish to testify to the favorable impression which I have received of it. There is no new device which comes into service, but what there will be some criticism or other of it at first. I have gone through the experience of helping to introduce a great many things that are held as regular appliances for locomotive service nowadays, and in every case that I remember there was more or less difficulty. My impression of the locomotive stoker is that it is certainly as efficient now as the injector was when we got to first using it, just as efficient as the balance valve was when we got it first, and as was the case with many other things that might be mentioned if one should think of them all.

I feel certain that it is merely a matter of time when all heavy locomotives, not only in this country, but everywhere else, when it becomes beyond the capacity of a human being to fire them,

will be equipped with the mechanical stoker. You see it is getting to be nowadays that the capacity of the locomotive is the capacity of the fireman to maintain steam. When that capacity has been reached, it is only the part of engineering to get something better, something that you put power on instead of human muscle. I feel sure that several stokers already invented are capable of taking that place, and that automatic stokers will be as regular an appliance of locomotives ten years hence as the injector is to-day.

MR. C. A. SELEY (C. R. I. & P.): I think it is very gratifying to note the advance in the development of the automatic stoker for locomotives. As is well known, they are very extensively used in stationary practice, although the difficulties of applying them to a locomotive are much greater than in the case of a stationary boiler.

There is one point that might be mentioned in this connection, that, as the development of the stoker is not yet complete and it will be some time before the railroads can avail themselves of the perfected automatic stoker, we can ameliorate the work of the fireman considerably by handling his door for him instead of putting that labor on his hands. We have in use on the Rock Island a very large number of pneumatic door openers, the use of which enables the fireman to keep both hands on the shovel. The opening and closing of the door is no small part of the labor of firing, and it is a fact that our heavy doors are not closed, oftentimes, as they should be after the coal is put in.

MR. GEORGE L. FOWLER: I will add one word to the discussion. Mr. Morris's criticism, which he illustrated by the story of the Irishman who carried the bricks to the top of the ladder, for the man who laid the bricks, is not entirely out of place; but you must remember it is a different thing to stand at the back end of the cab, at the source of coal supply, raising it not more than 30 inches and putting it into the hopper in any old way, as long as it is put within the limits of the hopper, from what it would be to carry that same coal from the tender forward to the head of the boiler, open the door and throw it into the fire box and scatter it so that it will fall relatively even and alike in all parts of

of the stoker. I ask of how many members that committee will be composed?

THE PRESIDENT: That will be left to the Executive Committee.

MR. FEELEY (Southern Ry.): I suggest that this committee be appointed, and that the members of it be so selected that there will be a member on the committee from almost every district in the United States, so that we can get the benefit of their experiences with different classes of coal, and give the stoker a good test. The quality of the coal has something to do with the stoker, and I think good results would be accomplished by having the committee composed of gentlemen representing the various sections of the country.

THE PRESIDENT: That is good information for the committee, and they will undoubtedly take advantage of it.

Mr. Symons's motion for the appointment of the committee was then adopted.

On motion of Mr. Sinclair the discussion was closed.

THE PRESIDENT: We will now take up the discussion on "Relief and By-Pass Valves for Locomotives," to be opened by Mr. A. E. Manchester.

RELIEF AND BY-PASS VALVES.

MR. A. E. MANCHESTER (C. M. & St. P. Ry.): In opening the discussion on this subject I feel a little, as has been said by another gentleman, that I am doing it because I was asked to. I am a little in doubt as to just what thought the committee had in mind when they suggested this as a subject. My own observation and experience and practice is that we have practically two types of valve in use, one is an excess pressure valve, or sometimes termed a water valve, which is located in the cylinder heads or steam chests upon different designs of engines, and is intended to guard against an excess of steam pressure in the cylinders, steam chest, steam pipes and dry pipes, due to accumulations of water, or to excess pressure in the cylinders by the possible slipping of an eccentric, or due to the reversing of the engine with the main throttle closed.

As to how important it is thought that these excess pressure

throw the coal into a hopper and then it went through an opening which regulated the amount of coal supplied to the fire by a slide and underneath the slide was a corrugated cylinder which was rotating all the time, and that would throw the coal over the fire box and grates. I must say that it threw the coal very evenly on the grates, but it would deaden the fire down until it was necessary for the fireman to come along with a bar and raise the cakes of coal on edge, or we would not get any draft through the fire.

While I believe the mechanical stoker has come to stay, yet I think it would be well for people to consider the kind of stoker they are going to use in connection with the kind of coal they are going to use in the stoker. Since that time I have seen many stokers, and have paid particular attention to some mechanical stokers which were operating very successfully. I saw some at the water works in Kansas City, and also some large ones in Chicago, and for that matter in many other places in the country. Some of these stokers almost entirely eliminated the smoke nuisance. In some stokers they also obviated the necessity of opening the fire-box door by feeding the coal in. Many feed it in with a spiral carrier on the sides of the fire box and using grates set on an incline downwards to center, with another carrier taking the ashes away at the bottom. There are many different kinds. The stoker exhibited here is the Victor, I believe. I do not know how it would work with Missouri River slack. If it worked in the same way that the stokers worked which the Government installed, I would not want to be in charge of the plant using the stoker.

MR. W. S. MORRIS: I am glad to see the gentleman not so careful about the ethics of the Association with regard to omitting mentioning the names of patented articles. I wish to suggest to the committee, whoever they may be, that they will not omit to give the names of the stokers. We know that when a man gets a good thing, he has it patented and there is a prejudice in this Association against mentioning patented devices; but if any fellow has a patent on a good stoker, I hope the committee will give him the full benefit of it in their report.

MR. T. M. FEELEY (Southern Ry.): I believe there is a motion prevailing to appoint a committee to investigate the merits

of the stoker. I ask of how many members that committee will be composed?

THE PRESIDENT: That will be left to the Executive Committee.

MR. FEELEY (Southern Ry.): I suggest that this committee be appointed, and that the members of it be so selected that there will be a member on the committee from almost every district in the United States, so that we can get the benefit of their experiences with different classes of coal, and give the stoker a good test. The quality of the coal has something to do with the stoker, and I think good results would be accomplished by having the committee composed of gentlemen representing the various sections of the country.

THE PRESIDENT: That is good information for the committee, and they will undoubtedly take advantage of it.

Mr. Symons's motion for the appointment of the committee was then adopted.

On motion of Mr. Sinclair the discussion was closed.

THE PRESIDENT: We will now take up the discussion on "Relief and By-Pass Valves for Locomotives," to be opened by Mr. A. E. Manchester.

RELIEF AND BY-PASS VALVES.

MR. A. E. MANCHESTER (C. M. & St. P. Ry.): In opening the discussion on this subject I feel a little, as has been said by another gentleman, that I am doing it because I was asked to. I am a little in doubt as to just what thought the committee had in mind when they suggested this as a subject. My own observation and experience and practice is that we have practically two types of valve in use, one is an excess pressure valve, or sometimes termed a water valve, which is located in the cylinder heads or steam chests upon different designs of engines, and is intended to guard against an excess of steam pressure in the cylinders, steam chest, steam pipes and dry pipes, due to accumulations of water, or to excess pressure in the cylinders by the possible slipping of an eccentric, or due to the reversing of the engine with the main throttle closed.

As to how important it is thought that these excess pressure

valves are on a locomotive, I will say that it has generally been our practice to use them on all classes of engines. If we leave out this excess pressure valve, we have to take the entire responsibility of the rupture of the different parts due to an excess pressure, and I would not consider it wise to leave them off.

The other valve is the vacuum valve, or, as it is frequently described, the drifting valve. There is quite a variety as to details of construction, but the work to be performed by them all is about the same. The use of this particular valve has been criticized to some extent. A majority of them draw in air from the outside, it is said, which destroys the vacuum in the cylinder, and there has been some difficulty in some types of the valve, in keeping it in repair, although as a general proposition I do not feel that this is a serious objection or one to be seriously considered, because there are a lot of the valves that are not hard to maintain. The objection raised against the valve is that it lets cold air into the cylinders, cools off the walls and destroys the lubrication. I do not personally agree with that proposition, as I believe a vacuum valve is a good feature on an engine. In fact, there are some types of engines which would be very difficult to operate without them. Without the vacuum valve an engine in drifting must get the front end or other gases into the cylinder, or in the case of one or two types of the valve must swap the pressure from one end of the cylinder to the other. Several of these devices have proven to be quite delicate and hard to maintain.

My own judgment is that a properly constructed relief valve and vacuum valve are desirable, and that it will demonstrate itself on the pistons and valve stems if the valve is of proper size to do the work; if they are, you will find them running clean. If the valve is out of order and plugged, you will find the pistons and valve stems running black, showing that there are gases being drawn into the cylinder. I hope what I have said is enough to start this discusion.

MR. C. A. SELEY (C. R. I. & P. Ry.): My attention was recently called to the practice of a large Western road of taking off the vacuum relief valves, which action was based on the recommendation in a paper read at the St. Louis Railroad Club, I think in January last. It was stated in that paper that there was no

drawing back of the gases from the front end, as noted with the front end open to observation. Experimenters put articles over the exhaust nozzle when the engine was running at various positions of the lever and found that these were not drawn in. At the same time we know that the inside of the exhaust stand becomes coated with a black substance. It certainly does not come from the cylinder. On a road with which I was connected some years ago we tried the experiment of taking off the relief valves with the result that the rods and valve stems got very black and coated. It was the opinion of the mechanical department that the lubrication was affected thereby, although that is contrary to the opinion stated in the paper to which I refer, as they went to the extent of analyzing the deposit on the rods, and found it was not soot. It is a matter which can be settled possibly by other experiments, although, as I say, it is a practice of one large system to take them off quite extensively.

MR. W. E. SYMONS (K. C. So. Ry.): The subject of by-pass and relief valves to my mind is not entirely unlike the subject we have just passed, in that it pertains to a portion of locomotive equipment which is, in a certain sense, in an experimental stage; and as we have in recent years experienced quite a change from the old fixed custom of using only the Stephenson link and slide valve, or what might be called a conventional style of valve motion gear, fittings, etc., we now have various types of valve motion, particularly so different types of valves, by-pass valves, and relief valves; and it occurs to me that this is also an excellent subject for special committee work. As I know a number of roads have used different styles of valves that are recommended very highly, doubtless the results of their experiences, together with such experiments as might be conducted through a certain period of time, would enable the committee to arrive at certain conclusions which would be not only beneficial to all members of the Association, but the record in itself would be a valuable addition to the minutes of our proceedings and a credit to any library in which our minutes find a resting place.

MR. H. H. VAUGHAN (Can. Pac. Ry.): I would like to second Mr. Symons's motion in regard to a special committee on this matter. I think the subject is quite a live one at the present time. We

have cylinder head relief valves, steam chest relief valves, by-pass valves, and drifting valves, and the thing is getting pretty well mixed up. I do not believe that we are the only road on which cylinder head relief valves sometimes come in screwed down solid. My opinion is that we can get along as well with a larger cylinder cock as we can with a cylinder head relief valve. Some of our engines have even a drifting valve on the cylinder head, and that has been taken off without any bad results. It is a piece of apparatus which costs $30 to make; we lose the tops off of them, and there are other troubles, and they are a constant source of expense. They come in in all sorts of condition on the road, and the committee should see if they can do away with them.

I can not see the need of an excess pressure valve on high pressure steam chests. Very few of our engines run with a clearance of less than ten per cent, in the cylinder, and with ten per cent clearance the pressure in the steam chest cannot exceed 150 pounds in any event, since the amount of steam contained in the clearance will release itself at that pressure.

As far as by-pass valves are concerned, we have been very much pleased with the latest type of by-pass valve which has been applied by the American Locomotive Company. It has cost very little to keep up, but I would like to see some experiments made to find out whether it is advisable to apply that valve with its corresponding expense and cost of maintenance. I think this would be a good subject for a committee. My personal feeling is that on the ordinary simple engine, if we use a good size cylinder cock, an inch or an inch and a quarter, and a vacuum valve on the steam chest, we have about all we need to keep going.

MR. T. H. CURTIS (L. & N. R. R.): I think the high pressure relief valve is largely a matter of ornament. If you look at the engines equipped with them, you will generally find that the relief valve is full of grease and has not been used since the engine came out of the shop. In the first place, the engineer does not want it to be used, as he is afraid of it. If the relief valve is workable at a slight excess pressure, it is liable to work sometime when he is around it, and he is going to have it set so that it will not go off. A relief valve on the cylinder heads is never large enough to do any service. The Louisville & Nashville Railroad

had equipped nearly every engine with these high pressure relief valves. They were never used. We had a large number of cylinder heads broken. We changed the cylinder cocks from 3/8-inch to 3/4-inch and since making the change have had comparatively no more cylinder heads broken.

I think the vacuum valve is a necessity, but should be one which will fall open of its own accord, and its greatest use will be in drifting down hills and also while the engine is in the roundhouse it will be open and allow the leakage of the throttle to escape, and not cause the engine to run into the pit or through the wall.

MR. WM. MCINTOSH (C. R. R. N. J.): I agree with Mr. Vaughan's idea in regard to there being no necessity for the relief valve. We had some of our large engines equipped with them and found they were inoperative most of the time, and decided that by enlarging the cylinder cocks we could dispense with them altogether. We have done so and get much better results.

We consider the vacuum valve a necessity and have found it advisable with piston valve engines to raise the position of the vacuum valve as much as possible in order to throw the cold air away from the heated parts when the steam is shut off, thereby reducing materially the liability of cylinder fracture.

MR. S. W. MILLER (Penn. Lines): I would like to give a little experience I had in connection with the ordinary steam chest relief valve on the small consolidation engine. We had some little trouble with the valve stems breaking, and some one raised the question — I do not know who it was — as to whether they were of any value at all. I knew if we removed them from the steam chest and plugged the holes, that there would be adverse reports on it. We selected five of the engines and with the knowledge of only four men, the roundhouse foreman, the two men who did the work and myself, we plugged the valves on the inside. They ran from about the third of last January until the eighth of April without any one knowing there had been any change from our standard practice, and the only way it was found out then was by an engineer stepping out on a steam chest while the engine was running to oil the engine through the relief valve on account of his lubricator not working. After one of the men found it out everybody knew of it, of course. I had the lids lifted

and made a personal examination of the inside of the steam chest and the cylinders and there was absolutely no evidence of any excess of soot being drawn into the front end. I do not want to say that is conclusive evidence they are not of value, but it certainly points that way.

THE PRESIDENT: Mr. Symons, do I understand that you desire to make a motion that this subject of valves be referred to a special committee?

MR. SYMONS: Yes; I wish to make a motion to that effect — that the matter be referred to a standing committee. (The motion was duly seconded and carried.)

MR. DAVID BROWN (D. L. & W. R. R.): I am of opinion that the excess pressure valve should be eliminated; it is one of those devices that the air-brake has thrown out. In olden times when they used the reverse lever for braking purposes and you came on a flag, turned the reverse lever over readily, if you did not open the throttle, that is, provided the engine had not a pressure valve, why you would probably throw down the two steam chest covers on the ground. I have seen that happen. I have also seen the steam pipe burst on the cylinder, had to throw the cylinder away. If they opened the throttle that was overcome. But now that the brakes can be applied (and when the brakes are applied, the lever must not be thrown over), the excess pressure valve can be eliminated altogether. As the gentleman over there says, there are many of them that do not lift from the time they go out of the shop until they come in again; probably it would take three hundred pounds pressure to lift the most of them.

Regarding the relief valve, or air valve, I had an experience something the same as Mr. Miller, but I did not do it on the quiet; I did it openly. I had it both in freight service and passenger service. I had three passenger engines equipped with it and one of the three engineers came to me and said, "Mr. Brown; you will have to put that air valve in again." "What is the matter?" "Oh, she acts as if the steam chest was full of iron." I put them on the engines so that if the engineers were not satisfied they could replace them themselves, and that was done. That same engineer after he had run the engine with the air valves in again, came to me and said, "Take them out again, will you? I think

that I was a little too quick in forming a decision on the matter and I will try it again without the valve." We put the plugs in again and those three engines ran until there were orders to put them in by other parties. I also had several freight engines running, did not put them in the steam chest, did not put the hole in the steam chest. As Mr. Miller says, I never saw any sign of trouble from not having them in.

What started me at this was that there was a party who had a patented valve that he wanted to try; he used it on top of the main valve. The seat was screwed into the back of the valve and had a little valve which worked in it to change the operation when the throttle was shut, so that it made it an unbalanced valve. I concluded that if such a simple thing as that would do it, we could get along without anything.

MR. GEORGE W. WEST (N. Y. O. & W. Ry.): I would like to ask Mr. Miller whether, in the case he referred to, it was on a division where there was considerable coasting.

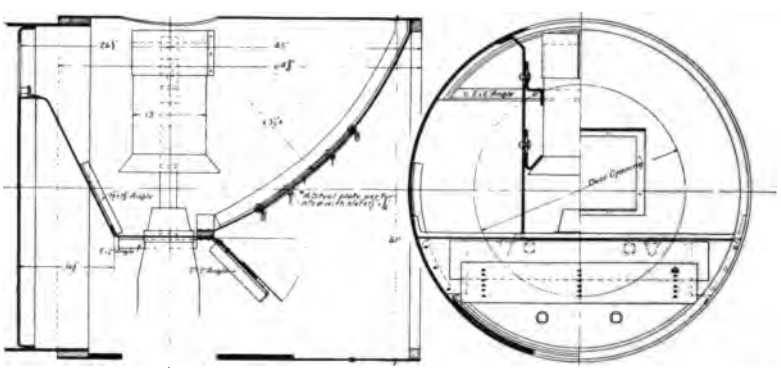
MR. S. W. MILLER (Penn. Lines West): It is quite an undulating division. There is one grade of 58 feet to the mile, some seven miles of it, and another one where freight trains drift for about fourteen miles. (On motion the discussion was closed.)

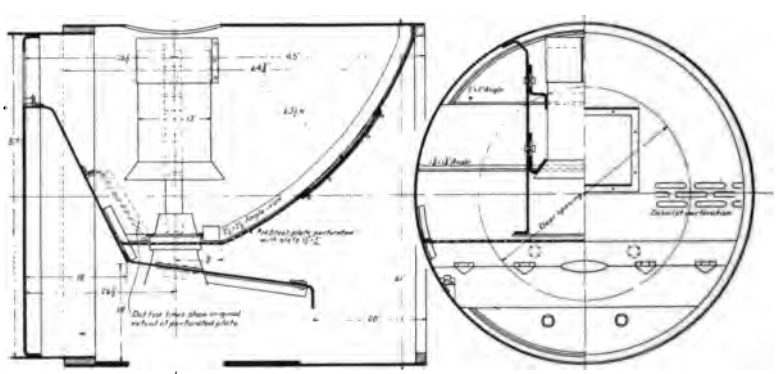
THE PRESIDENT: The next subject is "Are Engines with Self-Cleaning Front Ends Satisfactory?" to be opened by Mr. E. W. Pratt.

SELF-CLEANING FRONT ENDS.

MR. E. W. PRATT (C. & N.-W. Ry.): Mr. President and Gentlemen, I would say in the first place, to make this matter brief, as I think the period of experimentation has largely passed, that the consensus of opinion of the railroads that have largely equipped their modern power with self-cleaning front ends, is to the effect that they are satisfactory. To give a small amount of detail, I would say that on the Chicago & North-Western Railway, where we also think the self-cleaning front end is giving satisfaction, all the larger classes of power are so equipped. Out of 1,307 locomotives, over 600 have the self-cleaning front ends. We also have equipped a number of engines as small as 17 and 18 inch cylinders, with the new style front end, and it is giving sat-

isfaction. By comparing the amount of coal per 1,000 ton-miles for two successive years, the one before the changes in front ends were made, and the other the year following, we find the figures practically the same. As a matter of fact, it shows a three per cent saving, which I would only quote to indicate that we feel justified in saving that our fuel consumption is not increased at any rate on account of the self-cleaning feature. Some decided advantages are gained. Delays on the road due to dumping cinders from the old style front end are, of course, entirely eliminated; also the setting fire to the packing in the engine trucks due to hot cinders in dumping the front ends. There being no cinders to burn, we do not have the rims and the doors in front ends destroyed as formerly. This was particularly of great dis-





advantage with the pressed steel forms, which warped more readily than the cast iron. In changing the style of front ends we have not shortened up the extended front, which I believe would be of advantage in the way of obtaining better draft with still larger exhaust nozzles. On our territory, where we have a good deal of bad water, we wash out all boilers through the front flue sheet, hence the location of the apron, or extension on the diaphragm, is important; and I submit two blue-prints showing the advantage in this arrangement, whereby this apron is moved from behind the exhaust nozzle to a point ahead of it, with hinges and an arrangement for its adjustment, and also to raise it entirely out of the way for boiler washing.

MR. A. E. MITCHELL (L. V. R. R.): We all know that an engine always steams better when it first starts out on a trip. As the front end fills up with cinders we know that the engine does not steam so well, and therefore the fireman works all the harder. That I think is conclusive evidence that we can keep the front end clean if we burn less coal, make the work on the fireman less. I think that accounts for the three per cent saving Mr. Pratt has mentioned.

MR. GEORGE W. WEST (N. Y. O. & W.): All Ontario & Western engines are equipped with self-cleaning front ends. We have about fifty engines that are, not really consuming, but in which there is 250 or 300 pounds of material going through the fire box and flues per engine-mile, and in which it would be a very difficult matter to try to arrest the cinders. About sixty per cent of that material is other than fuel, yet we find that they are very economical engines. We could not undertake with those engines to arrest the sparks, and unless we can arrest them all I do not see any object in trying to arrest any of them. We know that in the old engines, in which we undertook to arrest the sparks, as soon as the engine filled up to a certain point, the live sparks would go out of the stack just as freely as with the non-arrester. We are very well satisfied with the self-cleaning front end and would not adopt anything else.

MR. W. G. WALLACE (D. M. & N. R. R.): In regard to the self-cleaning front end, I believe that the Master Mechanics' front end adopted as a standard by this Association is a self-cleaning

front end of itself, and I also work on the theory that the fewer appliances you can put in the front end of a locomotive to obstruct the draft, the better steaming engine you will have.

I recently had a little experience on about twenty-one consolidated engines, 22 by 28, with a front end very similar to or the same as that of the Master Mechanics, but they brought the diaphragm out directly away from the flues for about six inches at the top; and with a front end similar to this we found that our engines cleaned themselves perfectly. We have removed the hoppers on some, and on others we have put bolts through, and we have no trouble at all with this style of front end in cleaning itself, and have found it very satisfactory. Our engines have shown an evaporation of seven and eight pounds of water per pound of fuel.

MR. T. E. ADAMS (St. L. S. W. Ry.): We have about one hundred engines equipped with self-cleaning front ends, and one great advantage has been that it avoids the burning of the front door and door rim. We have had some trouble with front ends stopping up on the road, which necessitated opening the front door and cleaning the front end out; and in every case where the front end stopped up that way it was due to the netting becoming covered with a gummy substance that, of course, did not allow the cinders to go through. We determined that that was brought about either by the netting becoming wet — and there is nothing that will stop up a net in a front end so quickly as to have it become covered with water, which allows the cinders to adhere, and very quickly stops it up — that is one way in which a front end will stop up. Another way is, in pulling out of a station, if your fire is reasonably live on the grate, and the coal a little fine, the lifting of the fire from the grate before it has been thoroughly consumed, carries it through the flues and plasters the netting. In each case where delay had occurred, we took this up with the engineer and fireman, and largely overcame it. I believe the self-cleaning front end is up to date, I believe it is the best thing we have in that line, and it certainly does away with the expense of putting on hoppers, which leads to air being admitted to the front end and causing the front ends to burn out.

MR. G. E. PARKS (M. C. R. R.): I will say for your information that the Michigan Central R. R. considers the self-cleaning

front end entirely satisfactory. With front ends up to 60 inches in diameter the Master Mechanics' standard front end was used very successfully, and it is supposed to be entirely self-cleaning, because we do not put in the cleaning hoppers, and if it is not self-cleaning something is wrong with the adjusting plate and it is rectified. We found with smoke boxes larger than 60 inches, on the larger engines, that the Master Mechanics' front end of 1896 was not entirely satisfactory, but through some experiments and other adjustments we made a device that gave a very satisfactory front end for our compounds, and by a slight modification on all engines ordered we do away with the cleaning holes and cleaning hoppers, and have an entirely self-cleaning front end. That does not mean that all of the cinders are admitted to the stack, but the quantity is not large enough to cause any trouble with the draft.

MR. O. STEWART (Bangor & Aroostook R. R.): I have never in my experience in railroading, which has been of quite a number of years' duration, used anything but a self-cleaning front end. It is the easiest thing in the world to make an engine clean the front end. I have never adopted the Master Mechanics' standard for a front end. I simply use the diaphragm in the same way that it is customary to use it. It is all in front of the exhaust pipe. At the top it lies very near the exhaust pipe and at the bottom, or within twelve inches of the bottom, of the smoke arch it stands six inches off from the exhaust pipe. We do not have any sparks in our front end. We let them lie in the fire box, burn them up there. But with any device that you may put in it is possible to fill the front end of your engine with sparks. It is not the device you put in there that cleans the front end of your engine. It is the two men that stand on the footboard that fill them up, and my boys know if they bring their engines in with the front end filled up that they have to come and see me. Now, that is the kind of a cleaner I use. [Laughter.]

On motion, the discussion was closed.

THE PRESIDENT: The next matter is the report of the Committe on Subjects, which the Secretary will read.

REPORT OF COMMITTEE ON SUBJECTS.

To the Members:

The following is the report of the Committee on Subjects. It is divided into three parts, under the headings:

Subjects (for committees).

Topical discussions.

Individual papers.

The Committee also has appended to each item, as a recommendation or suggestion, the name of a member to open the discussion, prepare a paper, or the names of members to act on Committee.

TOPICAL DISCUSSION.

1. Best-known dimensions for water space around fire box to produce minimum consumption of fuel and replacement of fire-box sheets, and reasons for same.
Opened by Lawford H. Fry, Baldwin Locomotive Works.

2. Locomotive Stokers.
Opened by William Garstang.

3. Staybolts; results obtained from flexible staybolts.
Opened by T. S. Lloyd.

4. High-speed Steel. No reference to particular brand. Results being obtained from use of same.
Opened by J. A. Carney.

5. Relief and by-pass valves for locomotive cylinders. Are they necessary? If so, what is their function; what results are obtained from their use?
Opened by A. E. Manchester.

6. Are engines with self-cleaning front ends satisfactory?
Opened by E. W. Pratt.

INDIVIDUAL PAPERS.

1. The more general application of white metals for bearings of locomotives.

2. Special valve gears, such as the Walschaert, Alfree-Hubbell, Young, etc., compared with the ordinary Stephenson link motion.
Paper by C. J. Melin.

3. Fire kindling; cost of material, labor and time kindling fires in locomotives, with both anthracite and bituminous coal.
Paper by F. F. Gaines.

4. Superheating steam in locomotive practice.

Paper by F. J. Cole.

SUBJECTS AND COMMITTEES.

1. Best method of welding and repairing locomotive frames without taking down or removing from the engine.

William Garstang, C. H. Quereau, G. W. Wildin.

2. Organization of the Mechanical Department, with special reference to the question as to whether the Mechanical Department or the Transportation Department should employ, examine, promote, govern and discipline locomotive firemen and engineers.

D. Van Alstyne, J. H. Manning, G. M. Basford.

3. What can be done to establish a general understanding of a uniform method of designing repairs on locomotives in railroad repair shops, in order that reliable comparisons can be made as to the efficiency of various shops on any one system, or possibly as between the shops of various systems or roads.

H. H. Vaughan, R. Quayle, C. W. Cross.

4. Engine house running repair work on locomotives; what is considered the best practice for doing this work, handling reports, etc., made by foremen, engineers, road foremen of engines, and inspectors, and with what machine tools and hand tools should the roundhouse be equipped to get the best results?

A. E. Mitchell, F. T. Hyndman, J. W. Luttrell.

5. Locomotive lubrication; general consideration of the subject, with reference to high steam pressures and superheated steam; how far may we economize in lubrication, both internal and external; also consider standard fittings for lubricators; consider question of sight-feed lubricators versus pumps for internal lubrication.

E. D. Bronner, R. F. Kilpatrick, D. Van Alstyne.

6. Specifications covering cast iron to be used in cylinders, cylinder bushings, cylinder heads and steam chests; also the question of substitution of cast steel for locomotive cylinders, the idea being to secure lighter section with better material.

G. R. Henderson, E. D. Nelson, Max Wickhorst.

7. Results obtained from water-purifying plants.

L. H. Turner, H. T. Bently, W. R. McKeen.

J. F. Deems,
Wm. McIntosh,
R. D. Smith,
Committee.

Buffalo, January 12, 1905.

THE SECRETARY: I would move that the report of this Committee on Subjects be referred to the Executive Committee, so that it can consider the subject of individual papers and subjects and committees when it prepares the program for the next convention. (The motion was carried.)

THE PRESIDENT: The next subject is that of Correspondence and Resolutions.

In the absence of Mr. J. S. Chambers, chairman of the committee, the Secretary read the report as follows:

Resolved, That the hearty thanks of the Association be extended to the President for his able address; to the officers of the Association for their conscientious and painstaking work, and especially to the Secretary for the efficient and satisfactory services rendered the Association; to the Committee of Arrangements for their preparation for the convention; to Mr. J. P. Greaves, manager Oriental hotel; Mr. A. H. Silleck, manager Manhattan Beach hotel; and to Mr. Clark King, manager of the Brighton Beach hotel, for their hospitality and comforts provided for the members and guests of the Association; to the railroads and Pullman Company for the transportation courtesies extended to members; the Supply Men's Association, and especially Mr. Charles W. Martin, chairman of their Executive Committee, and their able secretary, Mr. J. Alexander Brown, for the entertainment of the members and guests, and for their instructive exhibits of railway machinery and supplies; and be it further

Resolved, That the thanks of this Association be extended to the railroads which have so liberally contributed to the Association in the matter of furnishing funds for the Committee on Tests of Locomotive Front Ends; and be it further

Resolved, That the thanks of the Association be extended to the *Railway Age* for its complete and accurate reports of the proceedings of the minutes.

J. S. CHAMBERS,
A. E. MITCHELL,
A. M. WAITT.

MR. J. D. BENJAMIN (Traveling Engineers' Assn.): Mr. President and Gentlemen, I wish to acknowledge the courtesy that you have granted in extending me the privilege of the floor. I assure you it is a great honor to meet with you and desire to thank you in behalf of the Traveling Engineers' Association, also extend my personal thanks for this privilege.

The Traveling Engineers' Association will hold their next

convention at Detroit and I extend a cordial invitation to you all to meet with us.

THE SECRETARY: Mr. President, before we go to the matter of the election of officers, I have the following notice received:

We hereby propose for associate membership in the American Railway Master Mechanics' Association, Mr. O. W. Bodler, editor, *Railway Master Mechanic,* Chicago. (Signed) A. E. Mitchell, J. F. Deems, F. M. Whyte.

This will take the regular course and lie on the table until the next convention.

MR. C. A. SELEY (C. R. I. & P. Ry.): Mr. President, pursuant to written notice read at the convention of this Association in 1904, I hereby propose the following resolution:

WHEREAS, On account of the growth of this Association and the additional burdens imposed thereby upon the officers, it is proposed to amend the constitution and provide for the election of six executive members, who, with the officers, shall constitute the Executive Committee as hereinafter provided.

This will be in accordance with the general plan of the organization of the Master Car Builders' Association.

Be it therefore

Resolved, That Article 4, Section 1; Article 6, Section 3, and Article 8, Section 1, be amended to read as follows:

"ARTICLE 4, SECTION 1: The officers of the Association shall be a president, a first vice-president, a second vice-president, a third vice-president, a treasurer, a secretary and six executive members, the six executive members, with the president, vice-presidents and the treasurer, shall constitute the executive committee.

"ARTICLE 6, SECTION 3: Five members of the executive committee shall constitute a quorum for the transaction of business.

"ARTICLE 8, SECTION 1: The officers of the Association, except the secretary, as hereinafter provided, shall be elected by ballot separately without nomination at the regular meeting of the Association held in June of each year. A majority of all votes cast shall be necessary to an election, and elections shall not be postponed. The president, vice-presidents and treasurer shall hold office for one year, and executive members for two years, or until successors are chosen; provided, however, that three executive members shall be elected for one year at the time of the adoption of this amendment. Three executive members shall be elected each year thereafter."

THE PRESIDENT: You have heard the amendment to the Con-

stitution and By-laws, which is made in conformity to announcement given at the convention one year ago. Now, what is your pleasure?

MR. ANGUS SINCLAIR: Mr. President, I move that it be adopted. (The motion was carried.)

THE PRESIDENT: Now, gentlemen, the next business in order is the election of officers for the ensuing year, and I will read for the benefit of those present, the officers who are now serving the association. (Reads the list of officers.)

The first in order will be the election by ballot of a President. I will appoint Mr. West and Mr. Morris as counting tellers, and Mr. Seley and Mr. Walsh as the collecting tellers.

THE SECRETARY: For the information of members I will read the constitution in regard to the election of officers. (Reads Article 8, Section 1.)

(A ballot was then taken for the office of President.)

THE SECRETARY: The tellers report that for the office of President there have been cast 83 votes. Necessary for a choice 44, of which Mr. H. F. Ball received 77; Mr. P. H. Peck, 1; Mr. F. J. Walsh, 1; D. R. MacBain, 1; J. F. Deems, 3.

THE PRESIDENT: It is my pleasure to announce that you have elected Mr. H. F. Ball as your President for the ensuing year.

MR. W. S. MORRIS: Mr. President, the vote is practically but not quite unanimous, and therefore I would offer a motion that the vote for Mr. Ball for President of the Association be made unanimous. (The motion was carried.)

A ballot was then taken for First Vice-President and the Secretary read the report of the tellers as follows:

Total votes cast 78, necessary for a choice 40.

J. F. Deems, 72; William McIntosh, 2; W. D. Robb, 1; G. W. Wildin, 1; H. H. Vaughan, 2.

THE PRESIDENT: I have the pleasure of announcing that you have elected Mr. J. F. Deems as First Vice-President of this Association for the ensuing year.

(On motion of Mr. McIntosh the election of Mr. Deems was made unanimous.)

A ballot was then had for Second Vice-President, with the following result: Total votes cast 83, necessary for a choice 42.

William McIntosh, 76; H. H. Vaughan, 4; George W. Wildin, 1; W. D. Robb, 1; J. F. Walsh, 1.

THE PRESIDENT: I therefore declare that you have elected Mr. McIntosh as your Second Vice-President of this Association for the ensuing year.

(On motion the ballot for Mr. McIntosh was made unanimous.)

A ballot was then taken for Third Vice-President, with the following result:

Total votes cast 93, necessary for a choice 47.

H. H. Vaughan, 49; George W. Wildin, 25; W. D. Robb, 1; A. E. Mitchell, 2; William McIntosh, 2; J. F. Walsh, 3; E. E. Davis, 1; F. H. Clark, 6; Theodore H. Curtis, 1; G. S. McKee, 1; A. E. Manchester, 2.

THE PRESIDENT: I have therefore the pleasure of announcing that you have elected Mr. Vaughan as your Third Vice-President for the ensuing year.

(On motion of Mr. McIntosh the vote for Mr. Vaughan was made unanimous.)

MR. ANGUS SINCLAIR: Mr. President, according to the amendment to the Constitution just adopted, there are six members of an executive committee to be elected, and they have to be chosen by ballot. I move that we proceed to elect these members of the Executive Committee by ballot.

THE PRESIDENT: Gentlemen, there are six directors to elect, three for one year and three for two years. So that there may be no mistake, you will prepare your ballots for three for two years, the three names on the same ticket.

A ballot having been taken in the meantime for the office of Treasurer, the Secretary at this point announced the report of the tellers upon that ballot as follows:

THE SECRETARY: The vote for Treasurer is as follows: There were 65 votes cast; necessary to a choice 33; Mr. Angus Sinclair received 65 votes. [Applause.]

The President declared Mr. Sinclair duly elected Treasurer for the ensuing year.

The Secretary then announced the report of the tellers on the ballot for members of Executive Committee for the term of two years as follows:

Ballots cast, 33; George W. Wildin, 17; W. G. Wallace, 3; C. A. Seley, 11; A. E. Mitchell, 12; R. F. Kilpatrick, 2; J. F. Walsh, 7; C. H. Hogan, 4; F. H. Clark, 4; W. D. Robb, 2; T. H. Curtis, 3; J. F. Deems, 1; John Howard, 2; W. O. Thompson, 2; W. E. Symons, 1; Prof. William F. M. Goss, 1; A. E. Manchester, 6; D. Brown, 1; William Cross, 2; T. E. Adams, 1; T. Johnson, 1; A. W. Gibbs, 1; J. J. Ellis, 1; J. H. Manning, 1; A. J. Pitkin, 1; D. F. Crawford, 1; J. S. Chambers, 1; C. E. Fuller, 1; D. Van Alstyne, 1; C. M. Mendenhall, 1; E. D. Bronner, 4; W. S. Morris, 1; P. H. Peck, 1.

MR. A. E. MANCHESTER (C. M. & St. P.): Mr. President, I move that the Secretary be instructed to cast the ballot for the three highest.

THE PRESIDENT: That would be Wildin, Seley and Mitchell. (The motion was carried.)

(The Secretary cast a ballot accordingly and Messrs. Wildin, Seley and Mitchell were declared duly elected members of the Executive Committee for the term of two years.)

A ballot was then taken for members of the Executive Committee for the term of one year, with the following result:

A. E. Manchester, 18; C. M. Mendenhall, 1; D. Van Alstyne, 3; H. T. Bentley, 1; A. W. Gibbs, 2; J. F. Walsh, 14; E. D. Bronner, 5; P. H. Peck, 1; F. H. Clark, 7; William Forsyth, 2; W. H. Lewis, 1; S. W. Miller, 1; R. F. Kilpatrick, 3; J. E. Muhlfeld, 2; H. J. Small, 2; J. H. Manning, 1; W. D. Robb, 5; A. J. Cota, 1; D. R. MacBain, 1; LeGrand Parrish, 2; McCarthy, 1; W. O. Thompson, 1; George W. West, 4; T. H. Curtis, 1.

THE PRESIDENT: The three receiving the highest votes are Messrs. Manchester, Walsh and Clark. I will entertain a motion for their election.

On motion the Secretary cast a ballot for Messrs. Manchester, Walsh and Clark, and they were declared duly elected members of the Executive Committee for the term of one year.

THE PRESIDENT: This clears up the business of the convention and I have pleasure in introducing your President whom you have elected for the ensuing year. [Applause.] I am glad to turn the gavel over to such an able and efficient officer. I know he will fill the position with gratification to himself and to the Association.

PRESIDENT-ELECT BALL: Gentlemen, I want to assure you that I appreciate the honor you have conferred on me in electing me to be President of the Association for the coming year. I esteem it a high honor, not only to be the highest officer of your organization, but also to have the privilege of following in the footsteps of the able men who have preceded me in this office. I feel that with the changes that have been made in the Constitution, whereby we will have more funds at our command, the Association is entering upon a new era of usefulness. I think that the forthcoming year ought to be fully as successful as this one has been. I want to compliment our Past President, Mr. Peck, on the splendid attendance he has had at the three sessions of this convention. I believe it has exceeded anything that we have heretofore had. As the hour is very late, gentlemen, I thank you again and will stop with that. [Applause.]

MR. L. R. POMEROY (General Electric Co.): I would like to offer a resolution of thanks to the retiring President for the manner in which he has conducted the affairs of the Association for this year. (The motion was carried unanimously.)

MR. PECK: I appreciate it very much, gentlemen, very much indeed.

THE SECRETARY: Mr. President, Mr. Chas. W. Martin, Chairman of the Executive Committee of the Supply Men's Association, would like to have the attention of this body for a couple of minutes, and I would like to ask that the privileges of the floor be extended to him.

THE PRESIDENT: If there are no objections, the privileges of the floor will be granted to Mr. Martin.

MR. MARTIN: Mr. President and Members of the American Railway Master Mechanics' Association. Time is very valuable at the present hour, and I am not going to keep you long. I wish to

say at this time a word as to the wonderful importance of your Association to the commercial business world. I wish to give you two facts relative to this convention. In 1904 we had 187 exhibitors at Saratoga. We now have on the grounds two hundred exhibits, and more are expected. In Saratoga we had 25,000 square feet of exhibition space; here we occupy 40,000 square feet. I think those figures speak for themselves.

Mr. Peck, as Chairman of the Executive Committee I have a duty to perform, and I only wish that I could do it as well as I feel. I have a little badge, or token, through which all of your friends wish to speak to you. They give it to you with the hope that every time you look at it you will remember that you have the good will of everyone in attendance at these conventions. I thank you, gentlemen. [Applause.]

MR. PECK: There is nobody that appreciates this token more than I do; they could not do it. I said last year when I was elected President of this Association that I had seen the second proudest day in my life; the first was when I was married, and the second when I was elected President of this Association. Now, you have added another to it. I am proud to receive this token from our commercial friends of the Supply Men's Association. Our Association and theirs are practically one. We can not get them apart; they go hand in hand. It reminds me of a sign I saw on a place where they colored goods. It said, "We dye to live, and we live to dye." Now, we live to buy, and they live to sell, and we are all happy. I thank you, Mr. Chairman.

THE PRESIDENT: If there is nothing further to bring before the Association, a motion to adjourn will be in order.

Adjourned.

CIRCULAR RELATING TO LETTER BALLOT.

DEAR SIR,— At the convention of 1905 the following specifications were, on motion, ordered submitted to letter ballot for adoption as standard.

It might be stated that these specifications are similar to those adopted by the American Society for Testing Materials, with the exception that the reduction in area is 25 per cent instead of 35 per cent; also the bending test — 1 inch by ½ inch test piece 180 degrees over 1 inch diameter — is omitted, as it was not thought essential.

A.—PROPOSED SPECIFICATION FOR LOCOMOTIVE DRIVING AND ENGINE TRUCK AXLES.

MATERIAL.

1. Open-hearth steel.

CHEMICAL REQUIREMENTS.

2. Phosphorus, not to exceed..... .05 per cent.
Sulphur, not to exceed..... .05 per cent.
Manganese, not to exceed..... .60 per cent.

PHYSICAL REQUIREMENTS.

3. Tensile strength — not less than 80,000 lbs. per square inch.
Elongation in two inches — not less than 20 per cent.
Reduction in area — not less than 25 per cent.

TESTS.

4. One test per melt will be required, the test specimen to be taken from either end of any axle with a hollow drill, half-way between the center and the outside, the hole made by the drill to be not more than 2 inches in diameter nor more than 4½ inches deep. The standard turned test specimen, ½ inch in diameter and 2 inches gauge length, shall be used to determine the physical properties. (See Fig. 1.)

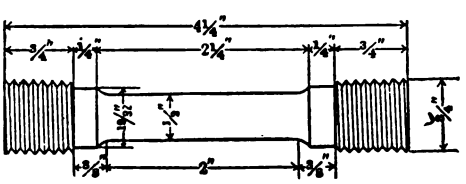


FIG. 1.

Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

5. Each axle must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than ⅜ inch high, and have order number plainly marked with white lead.

INSPECTION.

6. All axles must be free from seams, pipes and other defects, and must conform to drawings accompanying these specifications.

7. Axles must be rough-turned all over, with a flat-nosed tool, cut to exact length, have ends smoothly finished and centered with sixty-degree centers.

8. Axles failing to meet any of the above requirements, or which prove defective on machining, will be rejected.

B.— PROPOSED SPECIFICATIONS FOR LOCOMOTIVE FORGINGS.

1. Open-hearth steel.

CHEMICAL REQUIREMENTS.

2. Phosphorus, not to exceed..... .05 per cent.
Sulphur, not to exceed..... .05 per cent.
Manganese, not to exceed..... .60 per cent.

PHYSICAL REQUIREMENTS.

3. Tensile strength — not less than 80,000 lbs. per square inch.
Elongation — not less than 20 per cent in two inches.
Reduction in area — not less than 25 per cent.

TESTS.

4. One test per melt will be required, the test specimen to be cut cold from the forging, or full-sized prolongation of same, parallel to the axis of the forging and half-way between the center and the outside.

5. The standard turned specimen, ½ inch in diameter and 2 inches gauge length, shall be used to determine the physical properties. (See Fig. 1.) Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

6. Each forging must have heat number and name of manufacturer plainly stamped on one end with figures not less than 3/8 inch high, and have order number plainly marked with white lead.

INSPECTION.

7. All forgings must conform to drawings which accompany these specifications, and be free from seams, pipes and other defects.

8. Any forgings failing to meet any of the above requirements, or which prove defective on machining, will be rejected.

C.— PROPOSED SPECIFICATIONS FOR STEEL BLOOMS AND BILLETS FOR LOCOMOTIVE FORGINGS.

MATERIAL.

1. Open-hearth steel.

PHYSICAL REQUIREMENTS.

2. Grade "A":
   Tensile strength, 70,000 lbs. per square inch.
   Elongation in two inches, 20 per cent.

3. Grade "B":
   Tensile strength, 80,000 lbs. per square inch.
   Elongation in two inches, 17 per cent.

CHEMICAL ANALYSIS.

4. Grade "A":

Carbon	.25 to .40 per cent.
Phosphorus, not to exceed	.06 per cent.
Sulphur, not to exceed	.06 per cent.
Manganese, not to exceed	.60 per cent.

5. Grade "B":

Carbon	.35 to .50 per cent.
Phosphorus, not to exceed	.05 per cent.
Sulphur, not to exceed	.05 per cent.
Manganese, not to exceed	.60 per cent.

TESTS.

6. One test per melt will be required, the test specimen to be cut cold from the bloom, parallel to its axis and half-way between the center and the outside. The standard turned test specimen, ½ inch in diameter and 2 inches gauge length, shall be used to determine the physical properties. (See Fig. 1.) Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

7. Each bloom or billet must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than ⅜ inch, and have order number plainly marked with white lead.

INSPECTION.

8. Blooms and billets must be free from checks, pipes and surface defects. Any blooms or billets chipped to a depth greater than ½ inch will be rejected.

9. Any billet or bloom failing to meet the above requirements will be rejected and held subject to disposal by manufacturers.

10. Inspector to have the privilege of taking drillings from the center of the top bloom or billet of the ingot in order to determine the amount of segregation.

Grade "A" is intended for rod straps and miscellaneous forgings.

Grade "B" is intended for driving and truck axles, connecting rods, crank pins and guides.

The questions to be determined by this letter ballot are in accordance with paragraphs A, B and C, and each member is requested to vote by writing "Yes" or "No" opposite each question on the accompanying postal card, and remail it to the Secretary, 390 Old Colony building, Chicago, Illinois.

A vote "Yes" will mean that you are in favor of the proposed specifications as a standard of the Association, and a vote "No" will mean that you are not so in favor.

The votes will be counted August 19, 1905, and any votes received after that date will be excluded from the count.

All votes must be either "Yes" or "No" to be counted in the result, as no qualified votes will be considered.

JOS. W. TAYLOR,
Secretary.

LETTER BALLOT VOTING SLIP.

ARE YOU IN FAVOR OF

A. Specifications for Locomotive Driving and Truck Axles .....

B. Specifications for Locomotive Forgings .....

C. Specifications for Steel Blooms and Billets for Locomotive Forgings .....

Name.....

Road.....

Address.....

Title.....

RESULT OF LETTER BALLOT.

Chicago. Ill., August 21, 1905.

DEAR SIR:—The result of the Letter Ballot which closed August 19, 1905, is as follows:

SUBJECT.	Affirmative.	Negative.	Total.	Votes Necessary.	Result.
A. Specifications for Locomotive Driving and Truck Axles.....	141	10	151	101	Adopted.
B. Specifications for Locomotive Forgings.....	145	6	151	101	"
C. Specifications for Steel Blooms and Billets for Locomotive Forgings.....	139	11	150	100	"

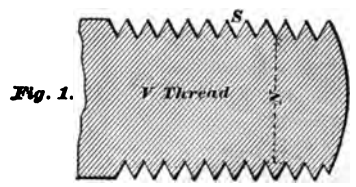
JOS. W. TAYLOR,

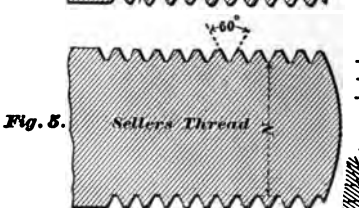
Secretary.

STANDARDS ADOPTED BY THE AMERICAN RAILWAY MASTER MECHANICS' ASSOCIATION.

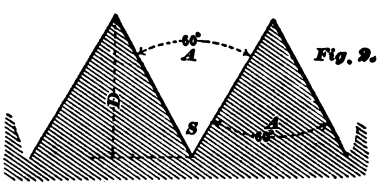
SCREW THREADS, BOLT HEADS AND NUTS.

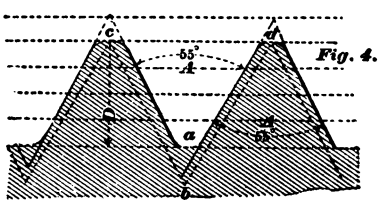
At the convention of 1870 the report of a committee recommending the United States Standard Screw Thread was adopted. The forms and dimensions of the threads are shown below:

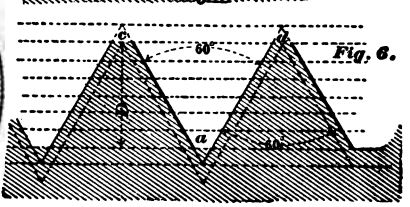




SCREW THREADS.







SELLERS' STANDARD.

Mr. Sellers, who proposed this system of screw threads, described it in an essay read before the Franklin Institute of Philadelphia, April 21, 1864, as follows:

"The proportions for the proposed thread and its comparative relation to the sharp and rounded threads, will be readily understood from the accompanying diagram in which Figs. 1 and 2 — the latter on an exaggerated scale — represent a sharp thread, Figs. 3 and 4 a rounded top and bottom to the English proportion, and Figs. 5 and 6 the flat top and bottom, all of the same pitch. The angle of the proposed thread is fixed at sixty degrees, the same as the sharp thread, it being more readily obtained than fifty-five degrees; and more in accordance with the general practice in this country. Divide the pitch, or, which is the same thing, the side of the thread into eight equal parts, take off one part from the top and fill in one part in the bottom of the thread, then the flat top and bottom will equal one-eighth of the pitch; the wearing surface will be three-quarters of the pitch, and the diameter of screw at bottom of the thread will be expressed by the formula:

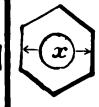
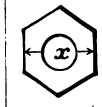
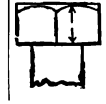
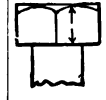
$$\textit{Diameter} - \frac{1{,}299}{\textit{number of threads per inch.}}$$

At the convention of 1892 the Association adopted as standard the United States standard sizes of nuts and bolt heads.

At the convention of 1903 the arrangement of these standards was made to conform to the arrangement as adopted by the Master Car Builders' Association.

The accompanying tables are reprinted from Mr. Sellers' essay. They give the proportions of his standard screw threads, nuts and bolt heads.

PROPORTIONS FOR SELLERS' STANDARD SCREW-THREADS, NUTS AND BOLTS.

Screw-Threads.				Nuts.				Bolt Heads.			
Diameter of screw.	Threads per inch.	Diameter at root of thread.	Width of flat.	Short diameter rough.	Short diameter finish.	Thickness rough.	Thickness finish.	Short diameter rough.	Short diameter finish.	Thickness rough.	Thickness finish.
											
$\frac{1}{4}$	20	.185	.0062	$\frac{1}{2}$	$\frac{7}{16}$	$\frac{1}{4}$	$\frac{3}{16}$	$\frac{1}{2}$	$\frac{7}{16}$	$\frac{1}{4}$	$\frac{3}{16}$
$\frac{5}{16}$	18	.240	.0074	$\frac{19}{32}$	$\frac{17}{32}$	$\frac{5}{16}$	$\frac{1}{4}$	$\frac{19}{32}$	$\frac{17}{32}$	$\frac{19}{64}$	$\frac{1}{4}$
$\frac{3}{8}$	16	.294	.0078	$\frac{11}{16}$	$\frac{5}{8}$	$\frac{3}{8}$	$\frac{5}{16}$	$\frac{11}{16}$	$\frac{5}{8}$	$\frac{11}{32}$	$\frac{5}{16}$
$\frac{7}{16}$	14	.344	.0089	$\frac{25}{32}$	$\frac{23}{32}$	$\frac{7}{16}$	$\frac{3}{8}$	$\frac{25}{32}$	$\frac{23}{32}$	$\frac{25}{64}$	$\frac{3}{8}$
$\frac{1}{2}$	13	.400	.0096	$\frac{7}{8}$	$\frac{13}{16}$	$\frac{1}{2}$	$\frac{7}{16}$	$\frac{7}{8}$	$\frac{13}{16}$	$\frac{7}{16}$	$\frac{7}{16}$
$\frac{9}{16}$	12	.454	.0104	$\frac{31}{32}$	$\frac{29}{32}$	$\frac{9}{16}$	$\frac{1}{2}$	$\frac{31}{32}$	$\frac{29}{32}$	$\frac{31}{64}$	$\frac{1}{2}$
$\frac{5}{8}$	11	.507	.0113	$1\frac{1}{16}$	1	$\frac{5}{8}$	$\frac{9}{16}$	$1\frac{1}{16}$	1	$\frac{17}{32}$	$\frac{9}{16}$
$\frac{3}{4}$	10	.620	.0125	$1\frac{1}{4}$	$1\frac{3}{16}$	$\frac{3}{4}$	$\frac{11}{16}$	$1\frac{1}{4}$	$1\frac{3}{16}$	$\frac{5}{8}$	$\frac{11}{16}$
$\frac{7}{8}$	9	.731	.0138	$1\frac{7}{16}$	$1\frac{3}{8}$	$\frac{7}{8}$	$\frac{13}{16}$	$1\frac{7}{16}$	$1\frac{3}{8}$	$\frac{23}{32}$	$\frac{13}{16}$
1	8	.837	.0156	$1\frac{5}{8}$	$1\frac{9}{16}$	1	$\frac{15}{16}$	$1\frac{5}{8}$	$1\frac{9}{16}$	$\frac{13}{16}$	$\frac{15}{16}$
$1\frac{1}{8}$	7	.940	.0178	$1\frac{13}{16}$	$1\frac{3}{4}$	$1\frac{1}{8}$	$1\frac{1}{16}$	$1\frac{13}{16}$	$1\frac{3}{4}$	$\frac{29}{32}$	$1\frac{1}{16}$
$1\frac{1}{4}$	7	1.065	.0178	2	$1\frac{15}{16}$	$1\frac{1}{4}$	$1\frac{3}{16}$	2	$1\frac{15}{16}$	1	$1\frac{3}{16}$
$1\frac{3}{8}$	6	1.160	.0208	$2\frac{3}{16}$	$2\frac{1}{8}$	$1\frac{3}{8}$	$1\frac{5}{16}$	$2\frac{3}{16}$	$2\frac{1}{8}$	$1\frac{3}{32}$	$1\frac{5}{16}$
$1\frac{1}{2}$	6	1.284	.0208	$2\frac{3}{8}$	$2\frac{5}{16}$	$1\frac{1}{2}$	$1\frac{7}{16}$	$2\frac{3}{8}$	$2\frac{5}{16}$	$1\frac{3}{16}$	$1\frac{7}{16}$
$1\frac{5}{8}$	$5\frac{1}{2}$	1.389	.0227	$2\frac{9}{16}$	$2\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{9}{16}$	$2\frac{9}{16}$	$2\frac{1}{8}$	$1\frac{9}{32}$	$1\frac{9}{16}$
$1\frac{3}{4}$	5	1.491	.0250	$2\frac{3}{4}$	$2\frac{11}{16}$	$1\frac{3}{4}$	$1\frac{11}{16}$	$2\frac{3}{4}$	$2\frac{11}{16}$	$1\frac{3}{8}$	$1\frac{11}{16}$
$1\frac{7}{8}$	5	1.616	.0250	$2\frac{15}{16}$	$2\frac{7}{8}$	$1\frac{7}{8}$	$1\frac{13}{16}$	$2\frac{15}{16}$	$2\frac{7}{8}$	$1\frac{15}{32}$	$1\frac{13}{16}$
2	$4\frac{1}{2}$	1.712	.0277	$3\frac{1}{8}$	$3\frac{1}{16}$	2	$1\frac{15}{16}$	$3\frac{1}{8}$	$3\frac{1}{16}$	$1\frac{9}{16}$	$1\frac{15}{16}$

PROPORTIONS FOR SELLERS' STANDARD NUTS AND BOLTS.

Rough Nut = one and one-half diameter of bolt + $\frac{1}{8}$.

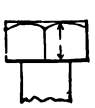
Finished Nut = one and one-half diameter of bolt + $\frac{1}{16}$.

Rough Nut = diameter of bolt.

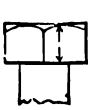
Finished Nut = diameter of bolt—$\frac{1}{8}$.

Rough Head = one and one-half diameter of bolt + $\frac{1}{8}$.

Finished Head = one and one-half diameter of bolt + $\frac{1}{16}$.



Rough Head = one-half distance between parallel sides of head.



Finished Head = diameter of bolt—$\frac{1}{16}$.

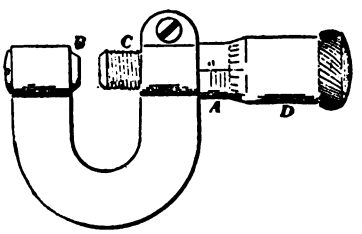
SQUARE BOLT HEADS.

In 1899 the following dimensions for square bolt heads were adopted as standard:

The side of the head shall be one and one-half times the diameter of the bolt, and the thickness of the head shall be one-half the side of the head.

SHEET METAL GAUGE.

At the convention of 1882 the Brown & Sharpe micrometer gauge shown below was adopted as standard for the measurement of sheet metal (see page 132, report 1882). Reaffirmed 1891 (see pages 160, 161, report 1891).



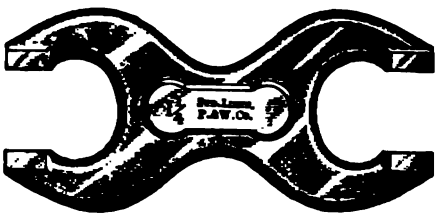
DISTANCE BETWEEN BACKS OF FLANGES.

At the convention of 1884 a motion prevailed that the standard distance between the backs of tires for tender locomotive truck and driving wheels be not less than 4 feet 5⅛ inches, nor more than 4 feet 5½ inches. (See page 26, report 1884.) Modified in 1903. See report of Committee on Revision of Standards.

LIMIT GAUGES FOR ROUND IRON.

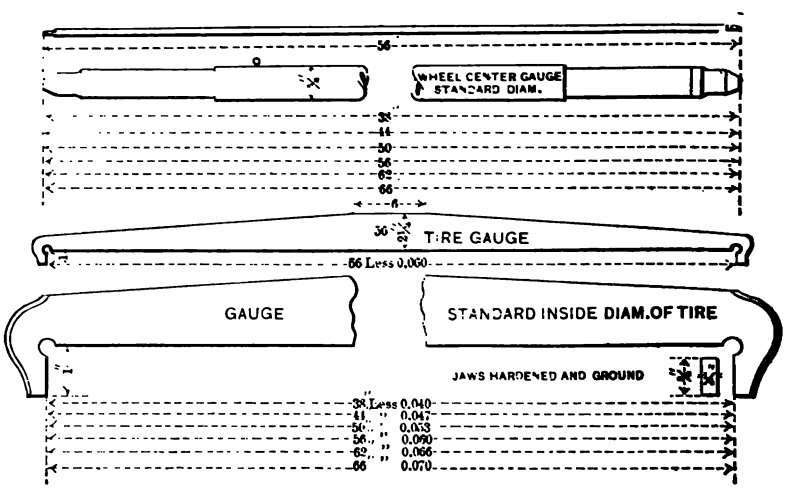
At the convention of 1884 the Pratt & Whitney limit gauges for round iron, shown below, were adopted as standard. (See page 168, report 1884.) Reaffirmed 1891 (see pages 160, 161, report 1891).

Nominal Diameter. Of Iron. Inches.	Large Size, End. Inches.	Small Size, End. Inches.	Total Variation. Inches.
1/4	.2550	.2450	.010
5/16	.3180	.3070	.011
3/8	.3810	.3690	.012
7/16	.4440	.4310	.013
1/2	.5070	.4930	.014
9/16	.5700	.5550	.015
5/8	.6330	.6170	.016
3/4	.7585	.7415	.017
7/8	.8840	.8660	.018
1	1.0095	.9905	.019
1 1/8	1.1350	1.1150	.020
1 1/4	1.2605	1.2395	.021



DRIVING WHEEL CENTERS AND SIZES OF TIRES.

At the convention of 1886 the report of a committee was adopted which recommended driving-wheel centers to be made 38, 44, 50, 56, 62 or 66 inches diameter. At the Twentieth Annual Convention the recommendations of a committee were adopted, making tire gauges manufactured by Messrs. Pratt & Whitney, Hartford, Connecticut, and here illustrated, standards of the Association. The sizes and the allowance for shrinkage are as follows:



At the Twenty-sixth Annual Convention the following sizes were adopted as standards for large driving wheels: 70, 74, 78, 82, 86 and 90 inches.

Reaffirmed in 1891 (see pages 160, 161, report 1891).

SECTION OF TIRE.

At the convention of 1893 the standard forms of tires shown on Plate 1 were adopted as standard. Railroad companies ordering tires will save time by specifying these forms.

At the convention of 1896 a minimum thickness of 1 inch for the flanges of engine and truck wheels was adopted as standard practice; determination to be made by M. C. B. flange thickness gauge. (See Proceedings for 1896.)

BOILER AND FIRE-BOX STEEL SPECIFICATIONS.

Adopted in 1894. (See pages 68-92, report 1894.) Revised June, 1904.

SPECIFICATION FOR BOILER AND FIRE-BOX STEEL.

MADE BY THE OPEN HEARTH PROCESS.

1. SPECIAL REQUIREMENTS FOR SHELL SHEETS.

This grade of steel is known to the trade as flange or boiler steel. The desired tensile strength is 60,000 pounds per square inch, with minimum and maximum limits 55,000 and 65,000 pounds. The elongation in eight inches shall not be less than twenty-five per cent for sheets three-quarters of an inch thick or under. For thicker sheets, deduct one per cent from specified elongation for each one-eighth inch additional thickness.

2. CHEMICAL REQUIREMENTS FOR SHELL SHEETS.

	Per cent.
Phosphorus shall not exceed (acid)	0.06
Phosphorus shall not exceed (basic)	0.04
Sulphur shall not exceed	0.05
Manganese	0.30 to 0.60

3. SPECIAL REQUIREMENTS FOR FIRE-BOX STEEL.

The desired tensile strength is 57,000 pounds per square inch, with minimum and maximum limits 52,000 and 62,000 pounds. The elongation in eight inches shall not be less than twenty-six per cent.

4. CHEMICAL REQUIREMENTS FOR FIRE-BOX SHEETS.

	Per cent.
Carbon	0.15 to 0.25
Phosphorus shall not exceed (acid)	0.04
Phosphorus shall not exceed (basic)	0.03
Sulphur shall not exceed	0.04
Manganese	0.30 to 0.50

GENERAL REQUIREMENTS.

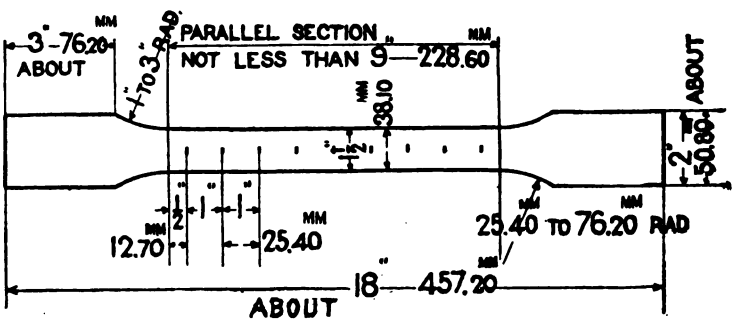
5. BENDING TESTS.

Test specimens for this purpose shall be 1½ inches wide, and for material ¾ inch or less in thickness shall be of the same thickness as that of the finished sheet. For sheets more than ¾ inch thick, the bending-test specimen may be ½ inch thick. The sheared edges of bending-test

specimens may be milled or planed. The cold bending test shall be made on the material in the condition in which it is to be used. The specimen for quench bending test shall be heated to a light cherry red, as seen in the dark, and quenched in water having a temperature between 80° and 90° F. Boiler steel and fire-box steel, before and after quenching, shall bend cold 180° flat on itself without fracture on the outside of the bent portion. The bending test may be made by pressure or by blows. One cold bending specimen and one quenched bending specimen will be furnished from each plate as it is rolled. The homogeneity tests for fire-box steel shall be made on one of the broken tensile test specimens.

6. SPECIMENS FOR TENSILE TEST.

Two tensile test specimens will be furnished from each plate as it is rolled. The standard test specimen of 8-inch gauged length shall be used for the tensile test. The standard shape of the test specimens shall be as shown by the following sketch:



PIECE TO BE OF SAME THICKNESS AS THE PLATE.

7. HOMOGENEITY TEST.

The homogeneity test for fire-box steel is made as follows: A portion of the broken tensile test specimen is either nicked with a chisel or grooved on a machine, transversely about a sixteenth of an inch deep, in three places about two inches apart. The first groove should be made on one side, two inches from the square end of the specimen; the second, two inches from it on the opposite side, and the third, two inches from the last and on the opposite side from it. The test specimen is then put in a vise, with the first groove about a quarter of an inch above the jaws, care being taken to hold it firmly. The projecting end of the test specimen is then broken off by means of a hammer, a number of light blows being used, and the bending being away from the groove. The specimen is broken at the other two grooves in the same way. The object of this

treatment is to open and render visible to the eye any seams due to failure to weld up, or to foreign interposed matter, or cavities due to gas bubbles in the ingot. After rupture, one side of each fracture is examined, a pocket lens being used if necessary, and the length of the seams and cavities is determined. The broken specimen shall not show any single seam or cavity more than ¼ inch long in either of the three fractures.

8. VARIATION IN WEIGHT.

The variation in cross section or weight of more than two and one-half per cent from that specified will be sufficient cause for rejection, except in the case of sheared plates, which will be covered by the following permissible variations:

Plates 12½ pounds per square foot or heavier, up to 100 inches wide, when ordered to weight, shall not average more than 2½ per cent variation above or 2½ per cent below the theoretical weight. When 100 inches wide and over five per cent above or five per cent below the theoretical weight.

Plates under 12½ pounds per square foot, when ordered to weight, shall not average a greater variation than the following:

Up to 75 inches wide, 2½ per cent above or 2½ per cent below the theoretical weight. Seventy-five inches wide up to 100 inches wide, five per cent above or three per cent below the theoretical weight. When 100 inches wide and over, ten per cent above or three per cent below the theoretical weight.

For all plates ordered to gauge there will be permitted an average excess of weight over that corresponding to the dimensions on the order equal in amount to that specified in the following table:

9. TABLE OF ALLOWANCES FOR OVERWEIGHT FOR RECTANGULAR PLATES WHEN ORDERED TO GAUGE.

Plates will be considered up to gauge if measuring not over 1-100 inch less than the ordered gauge.

The weight of 1 cubic inch of rolled steel is assumed to be 0.2833 pound.

PLATES ¼ INCH AND OVER IN THICKNESS.

Thickness of plate	Width of plate.			
	Up to 75 inches.	75 to 100 inches.	Over 100 inches.	Over 115 inches.
Inch.	Per Cent.	Per Cent.	Per Cent.	Per Cent.
1/4	10	14	18	....
5/16	8	12	16	....
3/8	7	10	13	17
7/16	6	8	10	13
1/2	5	7	9	12
9/16	4 1/2	6 1/2	8 1/2	11
5/8	4	6	8	10
Over 5/8	3 1/2	5	6 1/2	9

PLATES UNDER ¼ INCH IN THICKNESS.

Thickness of plate. Inch.	Width of plate. Up to 50 inches. Per cent	50 inches and above. Per cent.
1/8 up to 5/32	10	15
5/32 " 3/16	8 1/2	12 1/2
3/16 " 1/4	7	10

10. BRANDING.

Each sheet shall be stamped with the melt number and maker's name, and the test specimens cut from it shall be stamped with separate identifying marks or numbers, as may be specified by the purchaser.

11. INSPECTION.

The inspector, representing the purchaser, shall have all reasonable facilities afforded to him by the manufacturer to satisfy him that the finished material is furnished in accordance with these specifications.

STANDARD METHOD OF CONDUCTING EFFICIENCY TESTS OF LOCOMOTIVES.

In 1894 a method of conducting tests of locomotives was submitted by a committee of the Association, and on motion adopted as a standard of the Association. (See page 200, report 1894.)

The tests are as follows:

*A. Preparations for Test and Location of Instruments.**

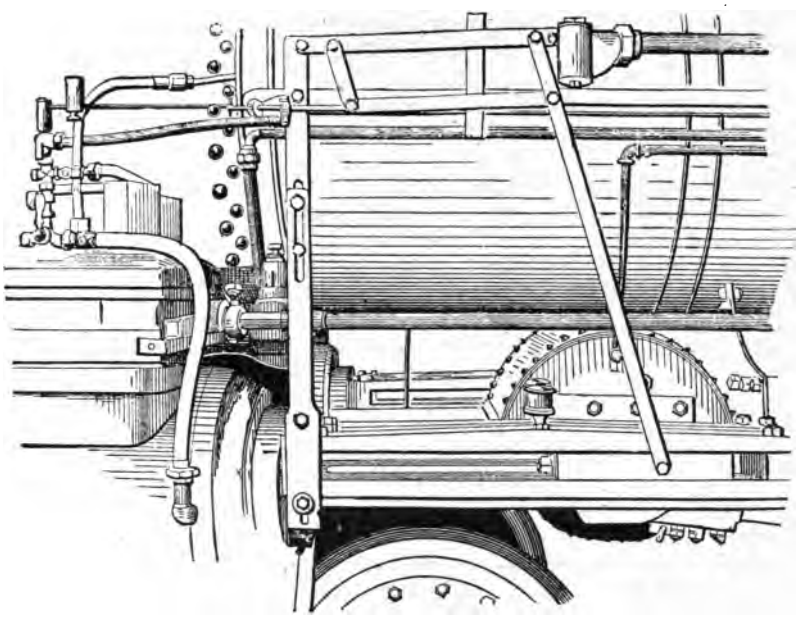
1. The locomotive should be put in good condition preparatory to the test. The boiler and tubes should be tight, and both the interior and exterior surfaces should be clean, and, if possible, free from scale. There should be no lost motion in the valve gear, and the valves should be set properly. No change in the engines should be allowed during the progress of a series of tests, unless so ordered for the purposes of the trial.

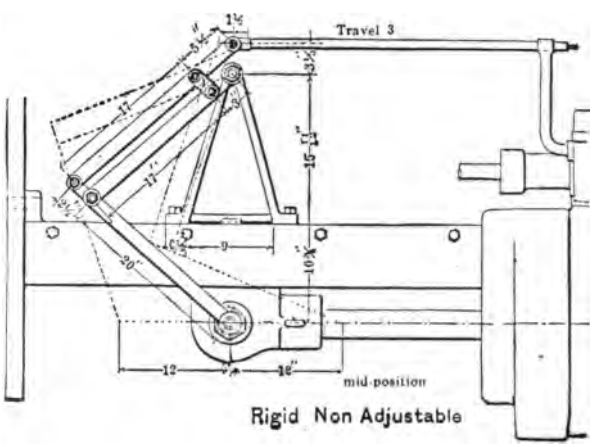
A glass water-gauge should be fitted to the boiler, if not already provided, and side of it there should be a graduated scale to assist in correcting water quantities, caused by change of inclination of the boiler, and difference of levels when beginning and ending a test. The notches on the quadrant should be marked by large figures, so that they can be read by the cab assistant. The throttle valve lever should be provided with a scale so as to show the degree of opening of the throttle valve.

The point of cut-off of the valves should be determined for each notch in the quadrant.†

* The directions here given apply largely to both shop and road tests, but especially the latter.

† See appendix for description of valve diagram apparatus used on Norfolk & Western Railway.





Rigid Non Adjustable

or other correct reducing motion for the driving rig. The pipes leading from the cock to the cylinder should be ¾ inch diameter inside, and they should connect into the side of the cylinder rather than into the two heads. The indicator should also be piped so that a steam-chest diagram can be drawn by it, and from this the steam-chest pressure determined. Sharp bends in the pipe should be avoided, and they should be well covered, to intercept radiation. The three-way cock should be provided with a clamp rigidly secured to the cylinder, and thus overcome any tendency of the indicators to move longitudinally with reference to the driving rig. Absolute rigidity is highly essential in this particular. Two forms of pantagraph motion are shown in Figs. 1 and 2. In both of these the reduced motion is transmitted to the indicator through a light rod, working horizontally. By this means a cord eight or ten inches in length is sufficient for connection to the indicator. Care should be taken to set the instrument in such a position that the cord pin in the end of the rod travels in a direction pointing to the groove in the paper drum. Pantagraph motions arranged as noted are preferable to the common pendulum and quadrant reducing mechanism, with its long stretch of cord. For another type of correct reducing motion see appendix.

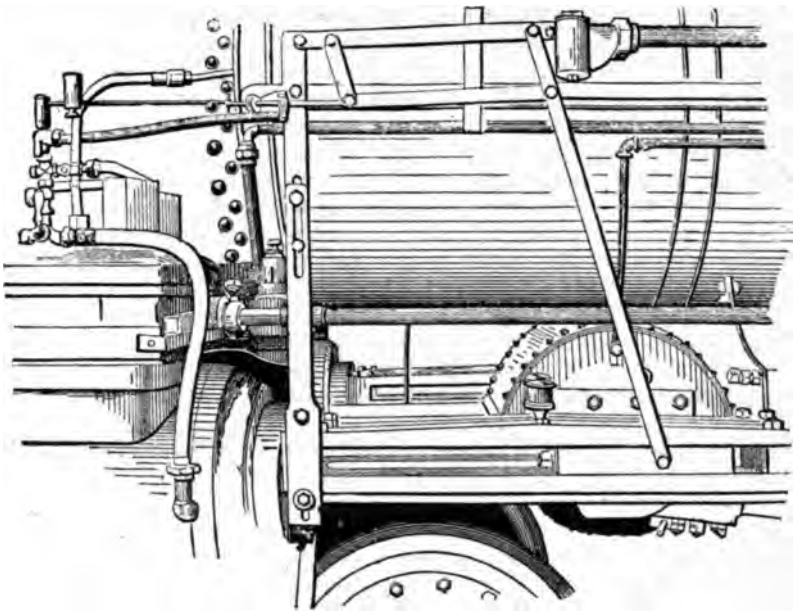
A draught gauge consisting of a U tube containing water, properly graduated in inches, should be placed in the cab and connected to the smoke-box by a ⅜-inch pipe. This long pipe steadies the water, and the readings can be taken by the cab assistant.

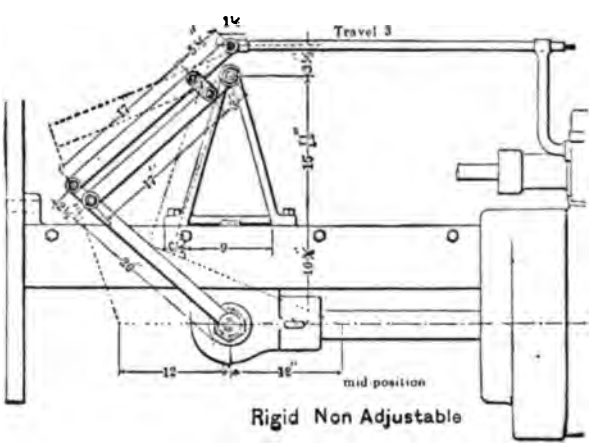
A pyrometer for showing the temperature of the escaping gases should be used in a position below the tip of the exhaust nozzles.

The calorimeter should be attached either to the steam dome at a point close to the throttle opening or to the steam passages in the saddle casting on one side, according as it is desired to obtain the character of the steam at one point or the other. The former location is preferred by the committee. A perforated ½-inch pipe should be used for sampling and conveying the steam to the calorimeter pipe. For descriptions of various forms of calorimeters which are adapted to locomotive use, see Trans. A. S. M. E., Vol. X, page 327; Vol. XI, page 790; Vol. XII, page 825.

The water meter should be attached to the suction pipe of the injector, and located at a point where it can be conveniently read when the locomotive is running. It should be provided with a check valve to prevent hot water from flowing back to it from the injector and a strainer to intercept foreign material.

To measure the depth of the water in the tank a metallic float should be used carrying a vertical tube which slides upon a graduated rod, the lower end of which rests upon the bottom of the tank. This should be placed at the center of gravity of the water space. If the desired location can not be used, provision should be made for ascertaining the level or inclination of the tank. The best device for this purpose is a plumb line of a certain known length, provided at the bottom with a double horizon-





Rigid Non Adjustable

tal scale having one set of divisions parallel to the side of the tank and the other set at right angles to it. From the readings on these scales referred to, the length of the line, the level of the tank in both directions can be ascertained. A similar device should be attached to the boiler to correct for the variation of its inclination.* The plumb line may be conveniently attached for this purpose at some point near the front end.

The revolution counter should be placed near the front end of the engine, in plain view of the pilot-box. It is operated through a belt from the driver axle. This recommendation applies to that form of counter which shows at a glance the exact speed in revolutions per minute.

A stroke counter should be provided for showing the number of strokes made by the air-pump.

Electric connection should be made between the dynamometer car and cab, so that dynamometer records and indicator diagrams may be taken simultaneously. Another desirable provision is a speaking-tube leading from the dynamometer car to the locomotive cab, and one also to the pilot-box.

7. It is needless, except for a complete record of directions for preparatory work, to call attention to the desirability of having the test, and especially the road test, made under the supervision of a competent person, who is not only familiar with the details of the testing, but also with the proper method of firing and mechanical operation of the locomotive. This is a most important factor, for it is only the clear-headed and able experimenter who is likely to obtain satisfactory work in this most difficult department of engineering tests.

The conductor of the test is best able to determine the number of assistants required, the various duties of the men, and the manner of making records. In general, three (3) men are sufficient to conduct a locomotive test, one (1) being at each cylinder, and one (1) in the cab for taking records.

The men at the cylinders will take indicator diagrams, and one will read the revolution counter and the pyrometer. The indicator papers will be numbered in consecutive order for each cylinder before the test begins, and when the diagram is taken the papers will be deposited through a slot in a box near each assistant.

The cab assistant notes the time of leaving and arriving at stations, the position and time of opening and closing the throttle, the time of taking indicator diagrams, for which he shall determine the time and give the signal by any effective means; the time of blowing off, the time the blower is applied, the number of applications of the injector, the position of the reverse lever, the steam pressure, the draught gauge, the time of passing important stations, the readings of the water glass, meter and air-pump counter, the number of sacks of coal used, the reading of the tank float, the temperature of the feed-water and atmosphere, the direc-

* See appendix for description of special devices used on the Norfolk & Western Railway for this purpose.

tion and force of the wind, the condition of the rail and state of the weather. Many of these readings are as nearly as possible simultaneous with the signal for taking indicator diagrams, and one experienced man in the cab will have no difficulty in entering all of these records in a note-book properly prepared with ruled columns and headings. In case of short stops at stations, one of the men at the indicators can take the tank float observations, or any observation that is advisable at stations. The weights of coal placed upon the tender have been checked by these two persons when weighing it out to the engine. One man takes the level of the boiler at stopping-places where this is required.

When the calorimeter and smoke-box gas samples are used another assistant is required.

In the dynamometer car two (2) men are required, who record the time of each start and stop, the time of passing each station and mile-post, time of taking each indicator diagram as obtained from the signal given by the cab assistant, and all these events are marked on the dynamometer paper. These men, as well as one of the engine assistants, will note the direction and force of the wind, the temperature of the atmosphere and condition of the weather.

8. It is of great importance, after the preparatory work has been accomplished, that a preliminary run be made with the locomotive, in order to fairly test the apparatus and to accustom the men to their duties.

B. The Dynamometer Car.

With a suitable dynamometer car the force required to move the train, or the pull upon the drawbar, is registered upon a strip of paper traveling at a definite rate per mile. The scale upon which this diagram is drawn should be as large as is possible within reasonable limits. A scale of ¼ inch per 1,000 pounds pull is suitable, as the maximum registered pull rarely exceeds 30,000 pounds.

The height of the diagram should be measured from a base line drawn upon the paper by a stationary pen, so located that when no force is exerted upon the drawbar the base line should coincide with zero pull.

The apparatus should be arranged to make a record of time marks in connection with the curve showing the pull. A chronometer should be provided having an electric circuit-breaker, by means of which a mark is made on the dynamometer paper every five (5) seconds. A better apparatus may be used in which a continuous speed curve is traced upon the paper parallel to the curve of pull. The ordinates of this curve, measured from a base line, give the speeds desired.

The location of mile-posts and other points along the route should be fixed upon the dynamometer paper by employing an additional pen, and operating it by means of electric press buttons, which are placed at convenient points in the car.

As already noted, a similar device should be provided for marking upon the dynamometer paper the time of taking indicator diagrams.

The rate of travel of the paper per mile should be such that one inch measured upon the diagrams represents 100 feet for short-distance work, and for long-distance work ½ inch to ¼ inch should be used to represent 100 feet of track. The driving mechanism for the paper should be so arranged that it can be changed to give these three proportions. It is necessary to have all the registering pens located upon the same transverse line at a right angle with the direction of the movement of the paper in order that simultaneous data may be recorded.

C. Method of Conducting the Road Test.

The locomotive having been brought to the train, the steam pressure being at or near the working point, the fire being clean and in good condition, the ash-pan being also clean, observations are taken, say, five (5) minutes before starting time, of the thickness and condition of the fire, the height of water in the boiler, the depth in the tank, the levels, the water meter and the air-pump counter, and thereafter the regular observations are carried forward, and coal is fired from the weighed sacks.

Indicator diagrams should be taken as frequently as possible, the intervals between them being not over two minutes.

Other regular observations should be taken at close intervals. Calorimeter readings, when taken, should be continued for at least five (5) minutes at one minute intervals.

At water stations careful records should be obtained of water heights and levels of boiler and tank.

As the end of the route is approached, the fire should be burned down so as to leave the same amount and the same condition as at the start. When the end is finally reached the fire should be raked and its condition carefully noted. If it differs from that which obtained at the beginning, an estimated allowance must be made for such difference.

At the close of the test the height of water in the boiler should be the same as at the beginning, or, if not, the difference, corrected for inclination of the boiler, should be allowed for.

During the process of weighing the coal into the sacks numerous samples should be obtained and placed in a covered box, and a final sample of these selected. This is to be dried and subjected to chemical analysis and calorimeter test. The sample is weighed before and after drying, and data obtained for determining the weight of dry coal used during the test. The temperature of the feed-water can be best taken at the tank cock, in order to obtain that of a mixed sample.

The duration of the road test is the length of time which the throttle valve is open.

D. The Data and Results.

The data and results of the road test may be tabulated in the form given in Table No. 1. This form corresponds in general with that recommended for shop test, namely, Table No. 2.

TABLE No. 1.

Data and Results of Road Test on....Engine, Made....189 .

General dimensions, etc. (to be accompanied by a complete description of engine with drawings and dimensions, also of train and route):

1. Kind of engine .....
2. Size of cylinders.....
3. Clearance of cylinders .....per cent
4. Area of heating surface .....sq. ft.
5. Area of grate surface.....sq. ft.
6. Size of exhaust nozzles .....inches
7. Average weight of locomotive and tender (including water)....tons
8. Number of cars .....
9. Weight of cars .....tons
10. Length of route .....miles
11. Number of ton-miles of train load .....ton-miles
12. Number of ton-miles of total load.....ton-miles
13. Schedule time of trips.....

Total Quantities.

14. Duration or time throttle valve is open .....hours
15. Weight of dry coal burned .....lbs.
16. Weight of water evaporated, corrected for moisture in the steam and loss at injector*.....lbs.
17. Weight of ashes and refuse taken from ash-pan.....lbs.
18. Weight of cinders from smoke-box .....lbs.
19. Percentage of ash as found by coal calorimeter test.....per cent
20. Total heat of combustion as found by calorimeter test ....B. T. U.
21. Results of chemical analysis of coal .....

Power Data.

22. Mean effective pressure, H. P. cyls.....lbs.
23. Mean effective pressure, L. P. cyls.....lbs.
24. Average revolutions per minute.....rev.
25. Indicated horse-power, H. P. cyls.....H. P.
26. Indicated horse-power, L. P. cyls.....H. P.
27. Indicated horse-power, whole engine.....H. P.
28. Pull on drawbar.....lbs.
29. Dynamometer horse-power .....H. P.

Averages of Observations of Instruments.

30. Average boiler pressure .....lbs.
31. Average steam-chest pressure .....lbs.
32. Average temperature of smoke-box..... °
33. Average drought suction..... "

* Should be corrected for steam used by calorimeter, air-pump, blower, safety valve and whistle, to find cylinder results—line 56.

34. Average temperature of feed-water..... °
35. Average temperature of atmosphere..... °
36. Average percentage of moisture in the steam.....per cent
37. Maximum percentage of moisture in the steam.....per cent
38. Weather, wind, etc.....

Other Data.

39. Average position of throttle.....
40. Average position of reversing lever.....
41. Average speed in miles per hour.....
42. Maximum speed in miles per hour.....
43. Number of stops.....
44. Average number of strokes of air pump per minute.....
45. Total estimated weight of steam used by air pump per hour.....lbs.
46. Estimated loss of steam at safety valve per hour.....lbs.
47. Estimated loss of steam at whistle per hour.....lbs.
48. Estimated weight of steam used by blower per hour.....lbs.
49. Estimated loss of steam at calorimeter per hour.....lbs.

Hourly Quantities.

50. Weight of dry coal burned per hour.....lbs.
51. Weight of dry coal burned per hour per square foot of grate surface .....lbs.
52. Weight of coal burned per square foot of heating surface.....lbs.
53. Weight of water evaporated per hour.....lbs.
54. Equivalent weight of water evaporated per hour with feed-water at 100° and pressure 70 lbs.....lbs.
55. Equivalent weight of water from 100° at 70 lbs. evaporated per square foot of heating surface.....lbs.
56. Weight of water consumed by engine cylinder (line 53, less sum of lines 45, 46, 47, 48 and 49).....lbs.

Principal Results — Complete Engine and Boiler.

57. Coal consumed per I. H. P. per hour.....lbs.
58. Coal consumed per dynamometer horse-power per hour.....lbs.
59. Coal consumed per ton-mile of train load.....lbs.
60. Coal consumed per ton-mile of total load.....lbs.
61. Weight of standard coal consumed per I. H. P. per hour.....lbs.
62. Weight of standard coal consumed per dynamometer horse-power per hour.....lbs.
63. Weight of standard coal consumed per ton-mile of train load....lbs.
64. Weight of standard coal consumed per ton-mile of total load.....lbs.

Boiler Results.

65. Water evaporated per pound of coal .....lbs.
66. Equivalent evaporation per pound of coal from and at 212°.....lbs.

67. Equivalent evaporation per pound of combustible from and at 212° .....lbs.

68. Heat imparted to each pound of steam used from average temperature of feed at average steam pressure in British thermal units.....

Cylinder Data.

69. Mean initial pressure above atmosphere.....lbs.

		H. P. Cyl.	L. P. Cyl.
70.	Cut-off pressure above zero.....lbs.	.....	.....
71.	Release pressure above zero .....lbs.	.....	.....
72.	Compression pressure above zero.....lbs.	.....	.....
73.	Lowest back pressure above or below atmosphere .....lbs.	.....	.....
74.	Proportion of forward stroke completed at cut-off	.....	.....
75.	Proportion of forward stroke completed at release	.....	.....
76.	Proportion of return stroke uncompleted at compression	.....	.....
77.	Mean effective pressure (lines 22 and 23) lbs.	.....	.....

Cylinder Results.

78. Total water consumed per indicated horse-power per hour, corrected for moisture in steam.....lbs.

79. Water consumed per I. H. P. per hour by cylinders alone (from line 56).....lbs.

		H. P. Cyl.	L. P. Cyl.
80.	Steam accounted for by indicators at cut-off.lbs.	.....	.....
81.	Steam accounted for by indicator at release.lbs.	.....	.....
82.	Proportion of feed-water used by cylinders (line 79) accounted for at cut-off.....	.....	.....
83.	Proportion of feed-water used by cylinders accounted for at release.....	.....	.....
84.	Total heat supplied by boiler to cylinders per hour in British thermal units.....	.....	.....
85.	Total heat supplied by boiler to cylinders per minute per indicated horse-power in British thermal units.....	.....	.....
86.	Total heat supplied by boiler to cylinders per minute per dynamometer horse-power in British thermal units	.....	.....

The following form for the tabulation of the results of locomotive tests will be found convenient. They can, of course, be modified to suit any method of testing, whether standard or not:

LOCOMOTIVE TESTS — GENERAL RESULTS.

.....*Railroad Co.*

.....*Tests of Locomotive No.....*, *between*.....

and.....*Distance*.....*Miles. Train No*.....

.....*Bound.* ....., *18*....

Kind of Coal..... *Coal Analysis*.....

Calorimetric Value of Coal.....

Trip No.....

Date .....

Left .....at.....

Arrived .....at.....

Left .....at.....

Arrived .....at.....

1. Weather .....
2. Mean temperature of atmosphere.....
3. Direction of wind.....
4. Velocity of wind, miles per hour.....
5. Condition of rails.....
6. Weight of train in tons of 2,000 lbs., including locomotive, tender, passengers and freight.....
7. Weight of train in tons of 2,000 lbs., excluding the locomotive and tender .....
8. Equivalent number of standard cars at .....tons each.....
9. Size of exhaust nozzle, single or double.....
10. Maximum boiler pressure by gauge.....
11. Minimum " " " " .....
12. Average " " " " ....
13. Prevailing position of throttle (wide open = 1.00).....
14. " " " reverse lever (notch) .....
15. " points of cut-off .....
16. Schedule time in motion.....
17. Actual " " " .....
18. Time made up in minutes.....
19. Aggregate intermediate stops, minutes.....
20. Time during which power was developed, or throttle open.....
21. Maximum number of revolutions per minute.....
22. Minimum number of seconds per mile.....
23. Maximum rate of speed, miles per hour.....
24. Average speed, miles per hour.....
25. Actual weight of coal fired.....

26. Moisture in coal, percentage.....
27. Dry coal fired.....
28. Actual weight of wood used.....
29. Total weight of coal fired (wood added at .4).....
30. Weight of refuse in fire-box and ash-pan.....
31. " unconsumed coal recovered from fire-box and ash-pan.....
32. Total weight of coal consumed (Item 29-31).....
33. Net weight of ashes in fire-box and ash-pan.....
34. Weight of cinders (sparks) in smoke-box.....
35. Percentage of ash in coal.....
36. " " cinders (sparks).....
37. " " total refuse.....
38. Percentage of combustible consumed.....
39. Weight of combustible utilized.....
40. Number of miles run per ton (2,000 lbs.) of coal.....
41. " " pounds of coal used per mile.....
42. Coal used per ton of train per 100 miles.....
43. " " " car-mile.....
44. Average weight of coal burned per square foot of grate surface per hour .....
45. Total coal per indicated horse-power developed per hour.....
46. Average temperature of feed-water.....
47. Weight of water drawn from tender.....
48. Waste of injector, leakage, etc.....
49. Weight of water apparently evaporated (Item 47-48).....
50. Percentage of moisture in steam.....
51. Water actually evaporated, corrected for quality of steam.....
52. Actual evaporation per pound of total coal.....
53. Equivalent evaporation from and at 212° per pound of coal.....
54. " " " " " " " " " " combustible.
55. Water used per ton of train per 100 miles.....
56. " " " car-mile .....
57. " " " hour while developing power.....
58. " " " indicated horse-power per hour.....
59. " " " sq. ft. of heating surface, from and at 212°.....
60. " " " " " " grate " " " " .....
61. Maximum indicated horse-power developed.....
62. Average " " " .....
63. Dry steam used per indicated horse-power, per hour, per indicator diagram .....
64. Average number of sq. ft. of heating surface per indicated horse-power
65. Average number of indicated horse-power per sq. ft. of grate surface.
66. Prevailing temperature in smoke-box while using steam.....
67. " draft in smoke-box while using steam, in inches of water.

SHOP TEST.

A. Preparation and Location of Instruments.

In preparing for a shop test the preparations described for the road test should be followed so far as the nature of the test requires. When run as a stationary engine the locomotive is not circumscribed by the conditions of road service, and many provisions required on the road are unnecessary. It is unnecessary to determine the quantity of steam consumed by the air pump and auxiliaries, for these are not brought into use on the shop test; and no occasion exists for finding the quantity lost at the safety valve, for on the continuous shop run the steam pressure can be maintained at a uniform point, and blowing off readily prevented. It is unnecessary to use sacks for the convenient measure of coal, because the coal can be readily weighed up in lots as fast as needed for the test. It is unnecessary to provide a "pilot-box," and no fixed location of the instruments is required, as on the road test. The feed-water may be weighed before it is supplied to the tank, and the tank may be used in this case as a reservoir, the float showing its depth. The meter would thus be unnecessary as the principal instrument of measurement, but a meter is in all cases useful as a check upon this most important element in the data. The long indicator pipes required on the road test may be dispensed with, and one indicator applied close to each end of the cylinder, a practice much to be preferred to the use of a three-way cock and the single indicator. The dynamometer car is not required, but its equivalent should be provided, consisting of a dynamometer which registers the pull on the drawbar in the same manner as the device used on the road.

The number of assistants required on a shop test is less than that needed for a road test. A good test can be made with four (4) assistants, distributed as follows:

One assistant for operating indicators.

One assistant for measuring water.

Two (2) assistants for general observations and coal measurement.

B. Conditions of Test.

The test should be continued for a run of at least two (2) hours from the time normal conditions have been established.

At the close of the test the water height in the boiler and the height of water in the tank should be the same as at the beginning, or proper corrections made for any differences which may exist.

The fire-box and ash-pit are then cleaned, and such unburnt coal as may be contained in the refuse is separated, weighed and deducted from the total weight of coal fired. The balance of the refuse is weighed, as also the cinders removed from the smoke-box.

During the progress of the test samples of the various charges of coal should be obtained, and at its close a final sample of these should be selected, dried and subjected to chemical analysis and calorimeter test.

The weight of the sample as taken before and after drying to ascertain the weight of moisture contained in the fuel.

C. The Data and Results.

The data and results of the shop test can best be arranged in the manner indicated in Table No. 2. So far as these are in common with the data and results obtained on the road test, the forms used on both kinds of test are identical.

TABLE No. 2.

*Data and Results of Shop Test on....Engine, made.....*189.....

General dimensions, etc. (to be accompanied by a complete description, with drawings and full dimensions).

1. Kind of engine.....
2. Size and clearance of cylinders.....
3. Area of heating surface.....
4. Area of grate surface.....
5. Diameter of exhaust nozzles.....

	Total Quantities.	Whole Run.
6.	Duration .....hrs.	.....
7.	Weight of dry coal burned, including .4 weight of wood.lbs.	.....
8.	Weight of water evaporated corrected for moisture in the steam .....lbs.	.....
9.	Weight of ashes and refuse from ash-pan.....lbs.	.....
10.	Weight of cinders from smoke-box.....lbs.	.....
11.	Percentage of ash as found by calorimeter test....per cent	.....
12.	Total heat of combustion per lb. coal as found by calorimeter test.....B. T. U.	.....
	Power Data.	
13.	Mean effective pressure, high-pressure cylinders.....lbs.	.....
14.	Mean effective pressure, low-pressure cylinders.....lbs.	.....
15.	Average revolutions per minute.....rev.	.....
16.	Indicated horse-power, high-pressure cylinders.....H. P.	.....
17.	Indicated horse-power, low-pressure cylinders.....H. P.	.....
18.	Indicated horse-power, total.....H. P.	.....
19.	Pull on drawbar .....lbs.	.....
20.	Dynamometer horse-power .....H. P.	.....
	Averages of Observations.	
21.	Average boiler pressure.....lbs.	.....
22.	Average steam-chest pressure.....lbs.	.....
23.	Average temperature of smoke-box.....°	.....
24.	Average draught suction....."	.....
25.	Average temperature of feed-water .....°	.....
26.	Average temperature of atmosphere.....°	.....
27.	Average percentage of moisture in the steam....per cent	.....
28.	Maximum percentage of moisture in the steam...per cent	.....

Hourly Quantities.

		Whole Run.
29.	Weight of dry coal burned per hour.....lbs.	.....
30.	Weight of dry coal burned per hour per square foot of grate surface.....lbs.	.....
31.	Weight of coal burned per hour per square foot of heating surface.....lbs.	.....
32.	Weight of water evaporated per hour.....lbs.	.....
33.	Equivalent weight of water evaporated per hour with feed-water at 100° and pressure at 70 lbs.....lbs.	.....
34.	Equivalent weight of water from 100° at 70 lbs. evaporated per square foot of heating surface.....lbs.	.....

Principal Results, Complete Engine and Boiler.

35.	Coal consumed per I. H. P. per hour.....lbs.	.....
36.	Coal consumed per dynamometer horse-power per hour .....lbs.	.....
37.	Weight of "standard coal" consumed per I. H. P. per hour .....lbs.	.....
38.	Weight of "standard coal" consumed for a dynamometer horse-power per hour.....lbs.	.....

Boiler Results.

39.	Water evaporated per pound of coal.....lbs.	.....
40.	Equivalent evaporation per pound of coal from and at 212°..... .....lbs.	.....
41.	Equivalent evaporation per pound of combustible from and at 212°.....lbs.	.....
42.	Heat imparted to each pound of steam used from average temperature of feed at average steam pressure in British thermal units.....	.....

Cylinder Data.

43.	Mean initial pressure above atmosphere.....lbs.		.....
		H. P. Cyl.	L. P. Cyl.
44.	Cut-off pressure above zero.....lbs.	.....	.....
45.	Release pressure above zero.....lbs.	.....	.....
46.	Compression pressure above zero.....lbs.	.....	.....
47.	Lowest back pressure above or below atmosphere .....lbs.	.....	.....
48.	Proportion of forward stroke completed at cut-off	.....	.....
49.	Proportion of forward stroke completed at release	.....	.....
50.	Proportion of return stroke uncompleted at compression	.....	.....

Cylinder Results.

		H. P. Cyl.	L. P. Cyl.
51.	Total water consumed per indicated horse-power per hour corrected for moisture in steam.....lbs.		
52.	Water consumed per I. H. P. per hour by cylinders alone (from line 51 less all measured losses).....lbs.		
53.	Steam accounted for by indicators at cut-off.lbs.	.....	.....
54.	Steam accounted for by indicators at release.lbs.	.....	.....
55.	Proportion of feed-water used by cylinders (line 52) accounted for at cut-off.....lbs.	.....	.....
56.	Proportion of feed-water used by cylinders accounted for at release .....lbs.	.....	.....
57.	Total heat supplied by boiler to cylinders per hour in British thermal units.....	.....	.....
58.	Total heat supplied by boiler to cylinders per minute per indicated horse-power in British thermal units.....	.....	.....
59.	Total heat supplied by boiler to cylinders per minute per dynamometer horse-power in British thermal units.....	.....	.....

Reports should give a copy of a set of sample indicator diagrams, also combined diagram (in case of compound engines) and a chart showing graphically the principal data.

SUPPLEMENT.

Description of Norfolk & Western Indicator Rigging. Fig. 1, General Arrangement. Fig. 2, Details.

This form of indicator rigging involves the use of a lever (supported from the running-board by a suitable bracket), and connected at its lower end to the cross-head (by a link 12 in. long). The indicator drum cord takes its motion from a square bar working in suitable guides and connected by a short link to the main lever. In order to secure a perfectly parallel motion, the length of the cross-head link should bear the same ratio to the length of the indicator-bar link as the full length of the main lever bears to the distance from fulcrum of main lever to point of connection of the indicator-bar link. For an engine with 24-inch stroke this ratio should be 1 to 6, in order to produce an indicator card 4 inches long, and the long and short links should be 12 inches and 2 inches, respectively.

Description of Valve Motion Indicator. Fig. 3.

In this apparatus a string is wound around the groove on one end of drum, and passed over proper pulleys until it leads off in a line with the motion of the cross-head, and the other end is attached to the cross-head,

so that any motion of the piston is communicated by the cord to the drum, causing corresponding rotation.

A cord from the pen-bar is led over suitable pulleys and attached to valve rod in the same manner. The combination of the two motions, as will be seen, will give an elliptical diagram in which the abscissæ represent the position of the piston, and the ordinates the position of the valve.

Description of Boiler Lever Indicator. Fig. 4.

This apparatus consists of a spirit level mounted in a saddle which slides on an arc of a large circle. This arc is graduated, and should be sufficiently curved to operate on the heaviest grade upon which the engine will be tested.

By putting the engine on jacks or cranes, and giving different elevations to the boiler, the height of water may be measured by means of a meter to certain points on the gauge-glass, and a corresponding table made, which will denote the quantity of water in the boiler for each different angular position of the boiler. These figures can be used to make corrections on the meter readings, allowing for inclinations of the track on which the engine is standing by simply pushing the spirit lever to a horizontal position and noting the reading on the indicator.

SPECIFICATIONS AND TESTS FOR IRON LOCOMOTIVE BOILER TUBES, EXTRA QUALITY.

At the convention of 1895 the following Specifications and Tests for Iron Locomotive Boiler Tubes were adopted as standard (see page 127, report 1895); modified in 1896 (see pages 332, 333, report 1896). Revised, June, 1904.

SPECIFICATIONS FOR IRON LOCOMOTIVE BOILER TUBES.

1. Tubes are to be made of knobbled, hammered charcoal iron, lap-welded.

2. Tubes must be of uniform thickness throughout, except at weld, where an additional thickness of .015 will be allowed. They must be circular within .02 inch, and the mean diameter must be within .015 inch of the size ordered. They must be within .01 inch of the thickness specified and not less than the length ordered, but may exceed this by .125 inch.

3. The minimum weights for tubes of various diameters and thicknesses are given in the following table:

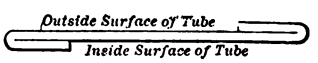
Outside Diameter.	Nominal B. W. G.	Thickness M. M. G.	Minimum weight per foot.
		Inches.	Lbs.
1¾ inch	No. 13	.095	1.65
	" 12	.110	1 89
	" 11	.125	2 07
	" 10	.135	2.29
2 inch	" 13	.095	1.91
	" 12	.110	2.17
	" 11	.125	2.38
	" 10	.135	2.64
2¼ inch	" 13	.095	2.16
	" 12	.110	2 46
	" 11	125	2.70
	" 10	.135	2.99
2½ inch	" 12	.110	2.73
	" 11	.125	3.02
	" 10	.135	3 37

SURFACE INSPECTION.

4. Tubes must have a smooth surface, free from all laminations, cracks, blisters, pits and imperfect welds. They must be free from bends, kinks and buckles, and from evidence of unequal contraction in cooling or injury in manipulation.

PHYSICAL TESTS.

5. Bending Tests.— Strips ½ inch in width by 6 inches in length, planed lengthwise from tubes, after having been heated to a cherry red and quenched in water at 80° F., shall bend in opposite directions at each end, as shown in sketch below, without cracks or flaws, and when nicked and broken by slight blows, these strips must show a fracture wholly fibrous.



6. Expanding Test.— Sections of tubes 12 inches long shall be heated a length of 5 inches to a bright cherry red in daylight and then placed in a vertical position and a smooth taper steel pin at blue heat will be driven into the end of the tube by light blows of a 10-pound hammer. Under this test the tube must stretch to 1⅛ times its original diameter without splitting or cracking. The pin used shall be of tool steel tapered 1½ inches to the foot. In making this test, care must be taken to see that the end of the tube is smoothly trimmed.

7. One tube is to be tested, as required in paragraphs 5 and 6, in each lot of 250 tubes or less.

8. CRUSHING TEST.— A section of tube 2½ inches long, when placed vertically on the anvil of a steam hammer and subjected to a series of light blows, must crush to a height of 1⅛ inches without splitting in either direction and without cracking or bending at weld.

9. HYDRAULIC TEST.— Before shipping, each tube must be tested by manufacturer to 500 pounds per square inch, and each tube must be plainly marked in the middle: "Knobbled charcoal, tested to 500 pounds pressure."

10. In addition to the above tests, tubes which, when inserted into boilers, split or break while being expanded or beaded, and also individual tubes which fail to pass surface inspection will be rejected and returned to the makers at their expense.

11. ETCHING TEST.— In case of doubt as to the quality of material, the following test shall be made to detect the presence of steel. A section of tube, turned or ground to a perfectly true surface on the end, will be polished free from dirt or cracks, and the end of the tube will be suspended in a bath of nine parts water, three parts sulphuric acid and one part hydrochloric acid. The bath will be prepared by placing water in a porcelain dish, adding the sulphuric and then the hydrochloric acid. The chemical action must be allowed to continue until the soft parts are sufficiently dissolved so that the iron tube will show a decided ridged surface, with the weld very distinct, while the steel tube will show a homogeneous surface.

SPECIFICATION FOR SEAMLESS, COLD DRAWN STEEL LOCOMOTIVE BOILER TUBES.

1. Tubes are to be cold drawn, seamless and made of open hearth steel. It is desired that the steel from which the tubes are manufactured should have the following chemical composition:

	Per cent.
Carbon	.15 to .20
Manganese	.45 to .55
Sulphur, below	.03
Phosphorus, below	.03

Tubes containing more than .03 phosphorus or sulphur will be rejected.

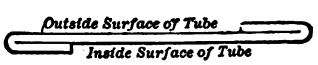
2. Tubes must be of uniform thickness throughout. They must be circular within .02 of an inch and the mean diameter must be within .015 inch of the size ordered. They must be within .01 inch of the thickness specified and not less than the length ordered, but may exceed this by .125 inch. They must be free from bends, kinks and buckles.

3. The minimum weights of the tubes of various diameters and thicknesses are given in the following table:

Outside Diameter.	Nominal B. W. G.	Thickness M. M. G.	Minimum weight per foot.
		Inches.	Lbs.
1¾ inch	No. 13	.095	1.69
	" 12	.110	1.92
	" 11	.125	2.15
	" 10	.135	2.29
2 inch	" 13	.095	1.91
	" 12	.110	2.19
	" 11	.125	2.47
	" 10	.135	2.65
2¼ inch	" 13	.095	2.16
	" 12	.110	2.48
	" 11	.125	2.80
	" 10	.135	3.01
2½ inch	" 12	.110	2.73
	" 11	.125	3.04
	" 10	.135	3.41

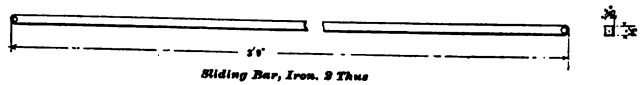
PHYSICAL TESTS.

4. Bending Test.— Strips ½ inch in width by 6 inches in length, planed lengthwise from tubes, after having been heated to a cherry red and quenched in water at 80 degrees F., shall bend in opposite directions at each end, as shown in sketch below without cracks or flaws.

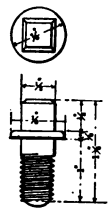


5. Expanding Test.— Sections of tubes 12 inches long shall be heated a length of five inches to a bright cherry red in daylight and then placed in a vertical position and a smooth taper steel pin at blue heat will be driven into the end of the tube by light blows of a 10-pound hammer. Under this test the tube must stretch to 1⅛ times its original diameter without splitting or cracking. The pin used shall be of tool steel tapered 1½ inches to the foot. In making this test care must be taken to see that the end of the tube is smoothly trimmed.

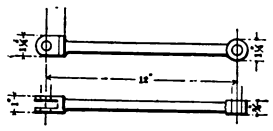
6. Crushing Test.— A section of tube 2½ inches long, when placed vertically on the anvil of a steam hammer and subjected to a series of light blows, must crush to a height of 1⅛ inches without splitting in either direction.



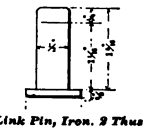
Sliding Bar, Iron. 2 Thus



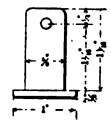
Clamp Screw, Iron. 2 Thus



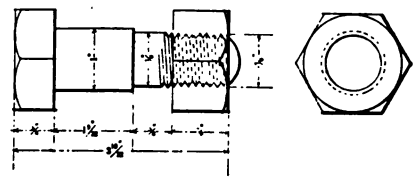
Connecting Rod, Iron. 2 Thus



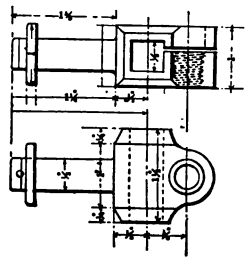
Link Pin, Iron. 2 Thus



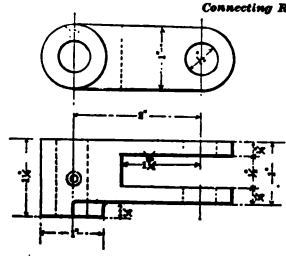
Connecting Rod Pin, Iron. 2 Thus



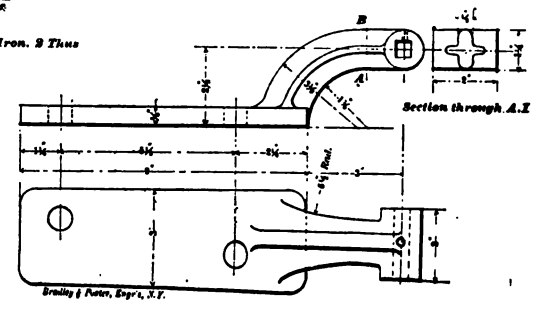
Indicator Lever Bolt, Iron. 2 Thus



Sliding Bar Clamp, Brass. 2 Thus



Connecting Link, Brass. 2 Thus



Sliding Bar Guide, Cast Iron. 4 Thus

FIGURE 2.

6th. The gauge must be plainly stamped with the words "Decimal Gauge" in capital letters .2 inch high, and below this the words "Master Mechanics."

7th. In ordering material, the term gauge shall *not* be used, but the thickness ordered by writing the decimal as in above list. For sizes over ¼ inch, the ordinary common fractions may be used.

BRIGGS STANDARD WROUGHT-IRON PIPE THREADS.

At the convention of 1899, what is known as the Briggs Standard, as determined by the Pratt & Whitney gauges, of threads for wrought-iron pipe and couplings, was adopted as a standard of the Association.

The gauges used by the Pratt & Whitney Company were made by them from an autograph copy of a table made by Mr. Robert Briggs personally, who originally established and published these standard threads. A copy of it is as follows:

STANDARD DIMENSIONS OF WROUGHT-IRON WELDED TUBES. BRIGGS STANDARD.

Diameter of Tube.			Thickness of metal.	Screwed Ends.	
Nominal inside.	Actual inside.	Actual outside.		Number of threads per inch.	Length of perfect screw.
Inches.	Inches.	Inches.	Inch.	No.	Inch.
⅛	0.270	0.405	0.068	27	0.19
¼	0.364	0.540	0.088	18	0.29
⅜	0.494	0.675	0.091	18	0.30
½	0.623	0.840	0.109	14	0.39
¾	0.824	1.050	0.113	14	0.40
1	1.048	1.315	0.134	11½	0.51
1¼	1.380	1.660	0.140	11½	0.54
1½	1.610	1.900	0.145	11½	0.55
2	2.067	2.375	0.154	11½	0.58
2½	2.468	2.875	0.204	8	0.89
3	3.067	3.500	0.217	8	0.95
3½	3.548	4.000	0.226	8	1.00
4	4.026	4.500	0.237	8	1.05
4½	4.508	5.000	0.246	8	1.10
5	5.045	5.563	0.259	8	1.16
6	6.065	6.625	0.280	8	1.26
7	7.023	7.625	0.301	8	1.36
8	7.982	8.625	0.322	8	1.46
9	9.000	9.688	0.344	8	1.57
10	10.019	10.750	0.366	8	1.68

Tapers of conical tube ends, 1 in 32 to axis of tube. (¾-inch per foot.)

By the late action of the Manufacturers of Wrought-Iron Pipe, 9-inch outside diameter has been excepted from the original list, as above noted, the diameter now adopted being 9.625 instead of 9.688 inches given in the Briggs table.

STANDARD PIPE UNIONS.

At the convention of 1902 standard dimensions for pipe unions ⅛ to 4 inches, inclusive, were proposed for adoption, and, at the convention of 1903, the same were adopted as standard. These dimensions are shown on Table A.

AXLES.

At the convention of 1879 the Master Car Builders' Standard Axle with 3¼ by 7 inch journals was adopted as standard. (See pages 14-35, 52-58, report 1879.) Changed to Recommendations 1891. (See pages 160, 161, report 1891.) Modified to conform to M. C. B. standard 1903. See plate 1.

At the convention of 1890 the Master Car Builders' standard axle with journals 4¼ by 8 inches was adopted as standard. See page 166, report 1890.) Changed to Recommendations in 1891. (See pages 160, 161, report 1891.) Modified to conform to M. C. B. standard in 1903. See plate 1.

At the convention of 1903 the Master Car Builders' standard axle with 5 by 9 inch journals was adopted as standard. See report of Committee on Revision of Standards, 1903. See plate 1.

At the convention of 1903 the Master Car Builders' standard axle with journals 5½ by 10 inches was made a standard. See report of Committee on Revision of Standards. See also plate 1.

JOURNAL BOX, BEARING AND PEDESTAL.

At the convention of 1881 a design of Journal Box, Bearing and Pedestal, as shown in figs. 1, 2 and 3, was submitted and made standard for cars and locomotive tenders. (See pages 110-115, report 1881.) Changed to Recommendations in 1891. (See pages 160, 161, report 1891.) Changed to standard in 1903. See plate 14.

At the convention of 1903 the M. C. B. journal boxes and contained parts for the 3¼ by 7 inch, 4¼ by 8 inch, 5 by 9 inch and 5½ by 10 inch standard axles, as shown on plate 1, were made a standard of the Association. They are shown on plates 2 to 13, inclusive.

SPECIFICATION FOR LOCOMOTIVE DRIVING AND ENGINE TRUCK AXLES.

MATERIAL.

1. Open-hearth steel.

CHEMICAL REQUIREMENTS.

2. Phosphorus, not to exceed..... .05 per cent.
   Sulphur, not to exceed..... .05 per cent.
   Manganese, not to exceed..... .60 per cent.

PHYSICAL REQUIREMENTS.

3. Tensile strength — not less than 80,000 lbs. per square inch.
Elongation in two inches — not less than 20 per cent.
Reduction in area — not less than 25 per cent.

TESTS.

4. One test per melt will be required, the test specimen to be taken from either end of any axle with a hollow drill, half-way between the center and the outside, the hole made by the drill to be not more than 2 inches in diameter nor more than 4½ inches deep. The standard turned test specimen, ½ inch in diameter and 2 inches gauge length, shall be used to determine the physical properties. (See Fig. 1.)

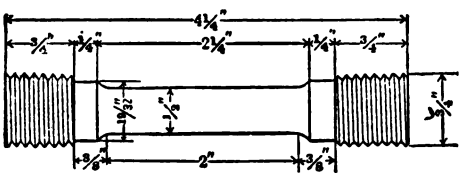


FIG. 1.

Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

5. Each axle must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than ⅜ inch high, and have order number plainly marked with white lead.

INSPECTION.

6. All axles must be free from seams, pipes and other defects, and must conform to drawings accompanying these specifications.

7. Axles must be rough-turned all over, with a flat-nosed tool, cut to exact length, have ends smoothly finished and centered with sixty-degree centers.

8. Axles failing to meet any of the above requirements, or which prove defective on machining, will be rejected.

SPECIFICATIONS FOR LOCOMOTIVE FORGINGS.

MATERIAL.

1. Open-hearth steel.

CHEMICAL REQUIREMENTS.

2. Phosphorus, not to exceed..... .05 per cent.
Sulphur, not to exceed..... .05 per cent.
Manganese, not to exceed..... .60 per cent.

5. Grade "B":

Carbon	.35 to .50 per cent.
Phosphorus, not to exceed	.05 per cent.
Sulphur, not to exceed	.05 per cent.
Manganese, not to exceed	.60 per cent.

TESTS.

6. One test per melt will be required, the test specimen to be cut cold from the bloom, parallel to its axis and half-way between the center and the outside. The standard turned test specimen, ½ inch in diameter and 2 inches gauge length, shall be used to determine the physical properties. (See Fig. 1.) Drillings or turnings from the tensile specimen shall be used to determine the chemical properties.

STAMPING AND MARKING.

7. Each bloom or billet must have heat number and manufacturer's name plainly stamped on one end, with stamps not less than ⅜ inch, and have order number plainly marked with white lead.

INSPECTION.

8. Blooms and billets must be free from checks, pipes and surface defects. Any blooms or billets chipped to a depth greater than ½ inch will be rejected.

9. Any billet or bloom failing to meet the above requirements will be rejected and held subject to disposal by manufacturers.

10. Inspector to have the privilege of taking drillings from the center of the top bloom or billet of the ingot in order to determine the amount of segregation.

Grade "A" is intended for rod straps and miscellaneous forgings.

Grade "B" is intended for driving and truck axles, connecting rods, crank pins and guides.

RECOMMENDATIONS.

At the convention in 1872 the following recommendations were adopted:

"In the matter of cost of keeping up the repairs of engines engaged in switching service exclusively, that an allowance of six miles per hour for the time that such engines are in actual use be allowed:

"That for engines running local freight trains an allowance of six per cent to the train mileage be added for switching:

"That where engines run empty to exceed one-half mile between where the trains are taken or left and the roundhouse, such mileage should be computed, and that for engines running through freight or passenger trains no computation should be made for switching:

SPECIFICATIONS AND TESTS FOR CAST-IRON WHEELS.

At the convention of 1888 the following Specifications and Tests for Cast-iron Wheels were adopted as standard. (See pages 151-154, report 1888.) In 1891 these were changed to Recommendations. (See pages 160, 161, report 1891.)

The specifications and tests are as follows:

Specifications for Cast-iron Wheels.

1. The chills in which the wheels of any one wheelmaker are cast shall be of equal diameters, and the same chill must not vary at different points more than one-sixteenth of an inch in diameter.

2. There shall not be a variation of more than one-half inch in the circumference of any given number of wheels of the same nominal diameter, furnished by any one maker, and the same wheel must not vary more than one-sixteenth of an inch in diameter. The body of the wheel must be smooth and free from slag or blow holes. The tread must be free from deep and irregular wrinkles, slag, chill cracks and sweat or beads in the throat which are one-eighth of an inch or over in diameter, or which occur in clusters of more than six inches in length.

3. The wheels broken must show clean, gray iron in the plates; the depth of pure white iron must not exceed seven-eighths of an inch or be less than three-eighths of an inch in middle of the tread, and shall not be less than three-sixteenths of an inch in the throat. The depth of the white iron shall not vary more than one-fourth of an inch around the tread on the rail line in the same wheel.

4. Wheels shall not vary from the specified weight more than two per cent.

5. The flange shall not vary in the same wheel more than three thirty-seconds of an inch from its mean thickness.

6. The single plate part of a 33-inch wheel, known as the Washburn pattern, shall not be less than five-eighths of an inch in thickness in a

wheel weighing from 550 to 575 pounds, and not less than three-fourths of an inch in thickness in a wheel weighing from 575 to 600 pounds.

Tests for Cast-iron Wheels.

1. For each hundred wheels which pass inspection and are ready for shipment, one representative wheel shall be taken at random and subjected to the following test:

The wheel shall be placed flange downward on an anvil block weighing seventeen hundred (1,700) pounds, set on rubble masonry at least two feet deep, and having three supports not more than five inches wide for the wheel to rest upon. It shall be struck centrally on the hub by a weight of one hundred and forty (140) pounds, falling from a height of twelve (12) feet. Should this wheel stand five (5) blows without breaking into two or more pieces, the hundred wheels shall be accepted. Or, wheels must be of such strength that 550 to 575 pound wheels shall require twenty (20) blows, and 575 to 600 pound wheels shall require thirty (30) blows of a hundred (100) pound drop falling seven (7) feet on the plate close to the rim to break a piece out — the wheel resting upon a cast-iron plate weighing not less than one thousand (1,000) pounds.

2. Should in either case the test wheel break into two or more pieces with less than the required number of blows, then a second wheel shall be taken from the same lot and similarly tested. If the second wheel stands the test, it shall be optional with the inspector whether he shall test a third wheel or not. If he does not so elect, or if he does and the third wheel stands the test, the hundred wheels shall be accepted.

3. The above tests shall apply to standard weight wheels from 26 inches to 42 inches diameter, used on standard gauge roads.

Form of Contract.

THIS INDENTURE, made this.....day of.....18.., between..... party of the first part, and.....party of the second part, WITNESSETH:

1. The party of the first part hereby agrees to furnish to the party of the second part, free on board cars at.....chilled cast-iron wheels, ... inches in diameter under the following conditions:

2. The party of the second part hereby agrees to pay to the party of the first part.....dollars for each wheel furnished, and to keep an accurate record of the mileage made by the wheels placed in service under cars in passenger equipment and under locomotives and tenders, and an accurate record of the number of months of service of the wheels placed under cars in freight equipment.

3. The party of the second part hereby agrees when any wheel furnished under this contract is scrapped, to furnish to the party of the first part a statement which will show

1.—The wheel number.

2.—The service in which the wheel ran.

3.—The amount of service in months or miles.

4.—The cause of failure.

5.—A charge against the party of the first part of fifty-five per cent (55 per cent) of the price of the wheel mentioned above.

6.—A credit to the party of the first part of

....cents per 1,000 miles for 36 in. passenger equipment
.... " " " 33 " " "
.... " " " 30 " " "
.... " " " 36 in. locomotives and tenders
.... " " " 33 " " "
.... " " " 30 " " "
.... " " " 28 " " "
.... " " " 26 " " "
.... " per month for 36 in. freight equipment
.... " " " 33 " " "
.... " " " 30 " " "

except in the case of wheels made flat by sliding, or removal for sharp flanges or other unfair treatment, which have not made sufficient service to balance the charge against the party of the first part as above; in such case a service credit shall be made which shall balance the charge.

4. The party of the first part hereby agrees that on presentation of the statement to pay to the party of the second part any balance due from lack of sufficient service on the part of the wheels (with above exceptions) to balance the charge; and the party of the second part hereby agrees to pay to the party of the first part any balance due as shown by the aforesaid statement — settlements to be made quarterly. It is, however, understood and agreed that no credit shall be allowed for excessive mileage for time service on freight wheels beyond the time guaranteed.

5. The party of the second part hereby agrees to hold, subject to the inspection of the party of the first part, for a period of thirty days after the said statement has been rendered, any wheels (with above exceptions) which have not earned for themselves a credit equal to the amount charged against them.

Service Guarantee.

36 inch passenger wheels.....	70,000 miles
33 " " "	60,000 "
36 inch engine and tender wheels	60,000 "
33 " " "	50,000 "
30 " " "	45,000 "
26 and 28 inch engine and tender wheels.....	40,000 "
Refrigerator, through line and cattle cars...	24 months
All other freight cars.....	48 "

Settlements of claims for non-performance of guaranteed service shall be made upon the basis of mileage and time guarantee as above.

AIR BRAKE AND SIGNAL INSTRUCTIONS.

At the convention of 1892 a code of Air Brake and Signal Instructions was adopted as Recommendation of the Association. Some modifications were made in 1898, and the modified rules are shown on pages 205-228, report 1898. Revised, June, 1904, as follows :

The title of the revised instructions should be,

"AIR BRAKE AND TRAIN AIR SIGNAL INSTRUCTIONS."

A.— GENERAL INSTRUCTIONS.

1. The following rules and instructions are issued for the government of all employes of this railroad whose duties bring them in contact with the maintenance or operation of the air brake and train air signal. They must be obeyed in all respects, as employes will be held responsible for the observance of same as strictly as for the performance of any other duty.

Every employe whose duties are connected in any way with the operation of the air brake will be examined from time to time as to his qualifications for such duties by the Inspector of Air Brakes or other person appointed by the proper authority, and a record will be kept of such examination.

A book of information will be issued, in convenient form, giving a complete explanation of such parts of the air brake and train air signal equipment as is deemed necessary for the care and operation of same. Any employe of this railroad whose duties require a knowledge of the operation and maintenance of the air brake and air signal will be furnished with a copy of same upon application at place designated by special notice, and every employe will be held responsible for a full knowledge of his duties in the operation or maintenance of the air brake or signal equipment.

B.— INSTRUCTIONS TO ENGINEMEN.

Enginemen when taking charge of locomotives must see that the air brake apparatus on engine and tender is in good working order, and that the air pump and lubricator work properly; that the devices used for regulating main reservoir and train pipe pressures are adjusted at the authorized amount; that brake valve works properly in all its positions; and that, when brakes are fully applied, with cam type of driver brake the pistons do not travel less than 2 inches nor more than 3½ inches, and with other forms from 4 inches to 6 inches, and that the tender brake piston does not travel less than 6 inches nor more than 9 inches. They must know that the air signal responds by opening hose cock on its train pipe.

Enginemen must report to roundhouse foremen, in writing, at the end of the run, any defects in the air brake or train air signal apparatus.

MAKING UP TRAINS, TESTING BRAKES AT TERMINAL POINTS AND BEFORE STARTING DOWN SUCH GRADES AS MAY BE DESIGNATED BY SPECIAL INSTRUCTIONS.— The train pipe under the tender must always be blown out and maximum pressure obtained in main reservoir before coupling engine to train.

After the train has been charged with air pressure, the engineman shall, at the request of the inspector or trainmen, apply the brakes with full service application and leave them so applied until all brakes operated from the engine have been inspected and the signal given to release. The engineman must then release the brakes and must not leave the station until it has been ascertained that all brakes are released and he has been informed by the inspector, or trainmen, of the number of brakes in service and their condition. In testing passenger brakes, the American Railway Association code of train air signals for applying or releasing must be used, one of which signals must be given from the discharge valve on rear car.

Following the separation of couplings for local switching, or when engine or train has been parted for any purpose, the above test need not be complied with further than to ascertain, by test, that the rear brakes are responsive to brake valve on engine and that all brakes have properly released. However, when cars are added to train, the brakes on such cars must be inspected as in terminal test. When a passenger train back-up hose is to be used to control the train, the brakes must be applied for test with the back-up hose, and released from the brake valve on the locomotive.

4. SERVICE APPLICATION.— In applying the brakes to steady the train on descending grades, or for reducing speed for any purpose, an initial train pipe reduction of not less than five pounds must be made. Releasing brakes at low speeds must be performed with great care, dependent upon local conditions.

With freight trains, first allow the slack to run up against the locomotive. Great care must then be taken to apply the brakes with five to nine pounds reduction, according to length of train pipe, and not make a second reduction until the effect of the first reduction is felt on entire train, in order to prevent shocks which otherwise might be serious. When a freight train must be brought to a full stop, the train brakes must be held applied until stop is made.

In making a service stop with a passenger train, ALWAYS RELEASE THE BRAKES A SHORT DISTANCE BEFORE COMING TO A DEAD STOP, except on heavy grades, to prevent shocks at the instant of stopping. Even on moderate grades it is best to do this, and then, after release, to apply the brakes lightly, to prevent the train starting, so that when ready to start the release will take place quickly.

5. EMERGENCY APPLICATIONS.— The emergency application of the brakes must not be used, except in actual emergencies. Under such conditions the brake valve must be left in emergency position until train has come to a full stop.

ENGINEMAN'S STRAIGHT AIR BRAKE VALVE ON LOCOMOTIVES.

a — Always keep both brakes cut in and ready for operation, unless failure of some part requires cutting out.

b — Always carry an excess pressure of ten pounds, or more, in the main reservoir, as this is necessary to insure a uniformly satisfactory operation.

c — When using the automatic brake, keep the straight air brake valve in release position; and when using straight air, keep the automatic brake valve in running position; this to avoid driver and tender brakes sticking.

d — The straight air reducing valve should be kept adjusted at forty-five pounds, and the driver and tender brake safety valves at fifty-three pounds.

When a full application of straight air causes either or both safety valves to operate, it indicates that same are out of order, or too high adjustment of the reducing valve or too low adjustment of the safety valve, or leakage of same. Have them tested and adjusted.

6. BRAKES APPLIED FROM AN UNKNOWN CAUSE.— If it is found that the train is dragging as though the brakes were applied, without rapid falling of the train line pointer, the engineman must make an effort to release the brakes, which may be done as follows: First, if train pipe pressure is less than the authorized amount and the required excess pressure is carried in the main reservoir, move the handle of the brake valve to the full release position for a few seconds and then return it to the running position; secondly, should the train pipe be fully charged with pressure, apply the brakes with a five or ten pounds reduction, according to the length of the train pipe, and release the brakes in the usual manner. In case the brakes can not be released, the train must be stopped and the trainmen notified to examine the brakes.

If, however, the brakes go on suddenly with a fall of the train line pointer, it is evidence that (a) a conductor's valve has been opened, (b) a hose has burst or other serious leak has occurred, or (c) the train has parted. In such an event, the locomotive throttle should be closed and the brake valve handle immediately placed on lap or emergency position, to prevent the escape of air from the main reservoir, and left there until the train has stopped and the brake apparatus has been examined and the signal to release given.

7. BRAKING BY HAND.— NEVER USE THE AIR BRAKE when it is known that the trainmen are operating the brakes of the air brake cars by hand,

except in cases of emergency, as there is danger of injury to the trainmen by so doing.

8. CUTTING OUT BRAKES.— THE DRIVER AND TENDER BRAKES MUST ALWAYS BE USED AUTOMATICALLY AT EVERY APPLICATION OF THE TRAIN BRAKE, unless defective, except upon such grades as shall be designated by special instructions.

When necessary to cut out either driver or tender brake, on account of defects, it shall be done by turning the handle of the four-way cock in the triple valve down to a position midway between a horizontal and a vertical position, first releasing the brake and leaving the bleed cock open. With the special types of triple valve, close the cut-out cock in the branch pipe.

9. DOUBLE HEADERS.— When two or more locomotives are coupled in the same train, the brakes must be connected through to and operated from the head engine. For this purpose a cock is placed in the train pipe, just below the brake valve. Engineman of each locomotive except the head one must close this cock and carry the handle of brake valve in running position. He will start his air pump and let it run, as though he were going to use the brake, for the purpose of maintaining air pressure on his locomotive and enabling him to assume charge of the train brakes should occasion require it.

10. AN EXTRA AIR-BRAKE HOSE, COMPLETE, must always be carried on the locomotive, for repairs in case of burst hose. Upon locomotives having the air signal, a signal hose, complete, must also be carried for the same purpose.

C.— INSTRUCTIONS TO TRAINMEN.

11. MAKING UP TRAINS AND TESTING AIR BRAKES.— When the locomotive has been coupled to the train, or when two sections have been coupled together, the brake and signal couplings must be united, the cocks in the train pipes — both brake and signal — must all be open, except those at the rear end of the last car, which must be closed, and the hose hung up properly in the dummy coupling, when cars are so equipped.

After the train has been charged with air, the engineman must then be requested to apply the brakes. When he has done so, the brakes of each car must be examined to see if they are properly applied. When it is ascertained that each brake is applied, the engineman must be signaled to release the brakes. (In testing passenger brakes the American Railway Association train air signal whistle code for applying or releasing must be used, one of which signals must be given from the discharge valve on the rear car.) The brakes of each car must then be examined to see that each is released, and the engineman informed as to the number of brakes in service and their condition.

If any defect is discovered it must be remedied and the brakes tested again — the operation being repeated until it is ascertained that every-

thing is right. The conductor and engineman must then be notified that the brakes are all right. Following the separation of couplings for local switching, or when engine or train has been parted for any purpose, the above test need not be complied with other than to ascertain, by test, that the rear brakes are responsive to brake valve on engine and that all brakes have properly released. At points where there are no inspectors, trainmen must carry out these instructions. No passenger train must be started out from an inspection point with the brakes upon any car cut out or in a defective condition, without special orders from the proper officers. The air brakes must not be alone relied upon to control any freight train with a smaller proportion of cars with the air brake in service than provided for by special instructions. When hand brakes are also used they must be applied upon those cars next behind the air-braked cars, except in cases of emergency.

12. Detaching Locomotive or Cars.— First close the cocks in the train pipes at the point of separation, and then part the couplings, invariably by hand.

13. Couplings Frozen.— If the couplings are found to be frozen together or covered with an accumulation of ice, the ice must first be removed and then the couplings thawed out by a torch to prevent injury to the gaskets.

14. Brakes Sticking.— If brakes are found sticking, the signal "brakes sticking" must be given as hereafter prescribed by the American Railway Association, or by special rules, in which case, if the brakes can not be released from the locomotive, or if the brakes are applied to detached cars, the release may be effected by opening the bleed cock in the auxiliary reservoir until the air begins to release through the triple valve, when the reservoir cock must immediately be closed.

15. Train Breaking Into Two or More Parts.— First close the cock in the train pipe at the rear of the first section and signal the engineman to release the brakes. Having coupled to the second section, observe the rule for making up trains — first being sure that the cock in the train pipe at the rear of second section has been closed, if the train has broken into more than two sections. When the engineman has released the brakes on the second section, the same method must be employed with refence to the third section, and so on. When the train has been once more entirely united, the brakes must be inspected on each car to see that all are released before proceeding.

16. Cutting Out the Brake on a Car.— If, through any defect of the brake apparatus, it becomes necessary to cut out the brake upon any car, it may be done by closing the cock in the cross-over pipe near the center of the car where the quick-action brake is used, or by turning the handle of the cock in the triple valve to a position midway between a horizontal and a vertical, where the plain automatic brake is used, first releasing the brake. With the special types of triple valves, close the cut-

out cock in the branch pipe. When the brake has been thus cut out, the cock in the auxiliary reservoir must be opened and left open upon passenger cars, or held open until all the air has escaped from the reservoir upon freight cars. THE BRAKE MUST NEVER BE CUT OUT UPON ANY CAR UNLESS THE APPARATUS IS DEFECTIVE, and when it is necessary to cut out a brake the conductor must notify the engineman and also send in a report stating the reason for so doing.

17. CONDUCTOR'S VALVE.— Should it become necessary to apply the brakes from the train, it may be done by opening the conductor's valve placed in each car so equipped. THE VALVE MUST BE HELD OPEN UNTIL THE TRAIN COMES TO A FULL STOP, AND THEN MUST BE CLOSED AGAIN.

This method of stopping the train must not be used except in case of emergency.

18. BURST HOSE.— In the event of the bursting of a brake hose, it must be replaced and the brakes tested before proceeding, provided the train be in a safe place. If it is not, the train pipe cock immediately in front of the burst hose must be closed, and the engineman signaled to release. All the brakes to the rear of the burst hose must then be released by hand, and the train must then proceed to a safe place where the burst hose must be replaced and the brakes again connected and tested, so as to ascertain that the rear brakes are responsive, by test, to the brake valve on engine. One extra air brake hose complete should be carried by all crews and one extra signal hose complete carried by passenger crews for repairs.

19. BRAKES NOT IN USE.— When the air brakes are not in use, either upon the road or in switching, the hose must be kept coupled between the cars or hung up properly to the dummy couplings, when cars are so equipped.

20. PRESSURE-RETAINING VALVE.— When this valve is to be used, the trainmen must, at the top of the grade, test the brakes upon the whole train, and must then pass over the train and turn the handles of the pressure-retaining valves horizontally upon all or a part of the cars, as may be directed. At the foot of the grade, the handles must all be turned downward again. Special instructions will be issued as to the grades upon which these valves are to be used.

21. TRAIN AIR SIGNAL.— In making up trains, all couplings and car discharge valves on the cars must be examined to see if they are tight. Should the car discharge valve upon any car be found to be defective, it may be cut out of use upon that car by closing the cock in the branch pipe leading to the valve. The conductor must always be immediately notified when the signal has been cut out upon any car, and he must report the same for repairs.

In using the signal, pull directly down upon the cord during one full second for each intended blast of the signal whistle, and allow three seconds to elapse between the pulls.

22. Reporting Defects to Inspectors.— Any defect in either the air brake or air signal apparatus discovered must be reported to the inspector at the end of the run; or, if the defect be a serious one in passenger service, it must be reported to the nearest inspector, and it must be remedied before the car is again placed in service.

D.— INSTRUCTIONS TO ENGINE-HOUSE FOREMEN.

23. General.— It is the duty of the engine-house foremen to see that the air brake and signal equipment is properly inspected upon each locomotive after each run. It must be ascertained that all pipe joints, connections and all other parts of the apparatus are air tight, duplex gauges tested every thirty days, and that the apparatus is in good working order.

24. Air Pump.— The air pump must be tested under pressure, and if found to be working imperfectly in any respect, it must be put into thoroughly serviceable condition.

25. Pump Governor.— The pump governor should cut off the steam supply to the pump when authorized pressure has been obtained.

26. Brake Valve.— This valve must be kept clean and known to be in working order in all its positions, before the locomotive leaves the engine-house.

27. Adjustment of Brakes.— The driver brakes must be so adjusted that the piston travel on the cam type will be not less than 2 inches nor more than 3½ inches, and in other forms not less than 4 inches nor more than 6 inches. When the cam brake is used care must be taken to adjust both cams alike, so that the point of contact of the cams shall be in line with the piston rod. The tender brake must be adjusted by means of the dead truck levers, so that the piston travels not less than six inches when the air brake is applied and the hand brake is released. This adjustment must be made whenever the piston travel is found to exceed nine inches.

28. Brake Cylinders and Triple Valves.— These must be examined, cleaned and lubricated at least once every six months. A record must be kept of the dates of last cleaning and lubrication of these parts for each locomotive.

29. Draining.— The main reservoir, and also the drain cup in the train pipe under the tender, must be drained of any accumulation after each trip. The auxiliary reservoirs and triple valves must also be drained frequently, and daily in cold weather, and the train pipe under the engine and tender blown out.

30. Air Signal.— The train air signal apparatus must be examined and tested by suitable appliances from both the head of the engine and the rear of the tender, to know that the whistle responds properly. A

pressure gauge must be applied to the air signal pipe once each month, and oftener if found to be necessary, to ascertain that the reducing valve maintains the authorized pressure per square inch in the train signal pipe.

E.—INSTRUCTIONS TO INSPECTORS.

31. GENERAL.—It is the duty of all inspectors to see that the couplings, the pipe joints, the triple valves, the high speed reducing valve, the conductor's valves, the air signal valves, and all other parts of the brake and signal apparatus are in good order, of standard size for the car and free from leaks. For this purpose they must be tested under the full air pressure as used in service. No passenger train must be allowed to leave a terminal station with the brake upon any car cut out, or in a defective condition, without special orders from the proper officer.

If a defect is discovered in the brake apparatus of a freight car, which can not be held long enough to give time to correct such defect, the brake must be cut out and the car properly carded, to call the attention of the next inspector to the repairs required.

Special rules will specify the smallest proportion of freight cars, with the air brakes in good condition, which may be used in operating the train as an air brake train.

32. MAKING UP TRAINS AND TESTING BRAKES.—In making up trains, the couplings must be united and the cocks at the ends of the cars all opened, except at the rear end of the last car, where the cocks must be closed; the inspector must know that the air is passing through the pipes to the rear end, and the couplings properly hung up to the dummy couplings if so equipped. After the train is fully charged the engineman must be requested to apply the brakes. When the brakes have been applied, they must be examined upon each car to see that they are applied with proper piston travel. This having been ascertained, the inspector must signal the engineman to release the brakes. (In testing passenger brakes the American Railway Association train air signal whistle code for applying or releasing must be used, one of which signals must be given from the discharge valve on the rear car.) He must then again examine the brakes upon each car to note that all have released. If any defect is discovered, it must be corrected and the testing of the brakes repeated, until they are found to work properly. The inspector must then inform both the engineman and conductor of the number of cars with brakes in good order.

This examination must be repeated if any change is made in the make-up of the train before starting.

HIGH SPEED REDUCING VALVES ON LOCOMOTIVES AND TENDERS must be tested at least once every month, and adjusted to authorized pressure, if necessary, and cleaned and lubricated at least once in three months, and oftner if tests show that same is necessary.

33. CLEANING CYLINDERS AND TRIPLE VALVES.— The brake cylinders and triple valves must be kept clean and free from gum. They must be cleaned and lubricated as often as once in six months upon passenger cars, and once in twelve months upon freight cars. The dates of the last cleaning and lubrication must be marked with white paint on the cylinder or reservoir, in the space left opposite the words:

Cylinder, cleaned and lubricated.....
Triple, cleaned and lubricated.....

The triple valves and auxiliary reservoirs must be frequently drained, especially in cold weather, by removing the plug in the bottom of the triple valve and opening the bleed cock in the reservoir.

34. GRADUATING SPRINGS.— The graduating springs in the Westinghouse quick-action freight triple valves are .049 inch in diameter, nickeled-steel wire, 16 coils, 2¾ inches free height, 29-64 inch inside diameter, and in passenger .08 inch diameter, nickeled-steel wire, 13¼ coils, 2⅝ inches free height, 29-64 inch inside diameter. The graduating springs used in the Westinghouse plain triple valve in locomotive service are made of phosphor-bronze wire, .083 inch in diameter, 12 coils, 2½ inches free height, 25-64 inch inside diameter.

35. ADJUSTMENT OF BRAKES.— The slack of the brake shoes must be taken up by means of the dead truck levers.

In taking up such slack it must be first ascertained that the hand brakes are off, and the slack is all taken out of the upper connections, so that the truck levers do not go back within one inch of the truck timber or other stop, when the piston of the brake cylinder is fully back at the release position. When under a full application the brake piston travel is found to exceed nine inches upon passenger or freight cars, the brake shoe slack must be taken up and the adjustment so made that the piston shall travel not less than six inches. In taking up the brake shoe slack it must never be taken up by hand brakes. Where automatic slack adjusters are applied to any car, such adjuster must be fully released before the slack is taken up elsewhere.

36. BRAKING POWER.— Where the cylinder lever has more than one hole at the outer end the different holes are for use upon cars of different weights.

It must be carefully ascertained that the rods are connected to the proper holes, so that the correct braking power shall be exerted upon each car.

37. REPAIR PARTS.— Inspectors must keep constantly on hand for repairs a supply of all parts of the brake and signal equipment that are liable to get out of order.

38. HANGING UP HOSE.— Inspectors must see that, when cars are being switched or standing in the yard, the hose is coupled between the cars or properly secured in the dummy couplings, when cars are so equipped.

39. RESPONSIBILITY OF INSPECTORS.— Inspectors will be held strictly responsible for the good condition of all the brake and signal apparatus upon cars placed in trains at their stations; they will also make any examination of brake apparatus or repairs to the same which they may be called upon to do by trainmen.

GENERAL QUESTIONS REGARDING THE USE OF THE AIR BRAKE AND TRAIN AIR SIGNAL.

GENERAL.

(All parties who have to do with the use, adjustment, care or repairs of air brakes should be thoroughly examined on these questions, in addition to the special questions for each class of men following them.)

1. Question. What is an air brake?

Answer. It is a brake applied by compressed air.

2. Q. How is the air compressed?

A. By an air pump on the locomotive.

3. Q. How does the compressed air apply the brakes?

A. It is admitted into a brake cylinder on each car, and it pushes out a piston in that cylinder, which pulls the brake on.

4. Q. How does the piston get back when the brakes are released?

A. There is a spring around the piston rod which is compressed when the brakes are applied, and when the air is allowed to escape to release the brakes, this spring reacts and pushes the piston in again.

5. Q. Where is the compressed air kept ready for use in the automatic air brake?

A. In the main reservoir on the locomotive, in the smaller or auxiliary reservoir on each car, and in the train pipe.

6. Q. Where does the compressed air come from directly that enters into the brake cylinder when the automatic brake is applied?

A. It comes from the auxiliary reservoir on each car in service application, and from the auxiliary reservoir and train pipe in emergency application.

7. Q. How does it get into the auxiliary reservoir?

A. It is furnished from the main reservoir on the locomotive through the train pipe and triple valve when the brakes are released.

8. Q. How is the automatic brake applied and released?

A. The automatic brake is applied by reducing the air pressure in the train pipe below that in the auxiliary reservoir, and is released by raising the train pipe pressure above that remaining in the auxiliary reservoir.

9. Q. Why does the compressed air not enter directly into the brake cylinder from the train pipe?

A. Because the triple valve used with the automatic brake prevents the air from entering directly from the train pipe to the brake cylinder when the pressure in the train pipe is maintained or increased.

10. Q. What other uses has the triple valve ?

A. It causes the brake cylinder to be opened to the atmosphere under each car, to release the brakes when the pressure in the train pipe is made greater than that in the auxiliary reservoir, and it opens communication from the train pipe to the auxiliary reservoir by the same movement; when the pressure in the train pipe is reduced it closes the openings from the train pipe to the auxiliary reservoir and from the brake cylinder to the atmosphere, and then opens the passage between the auxiliary reservoir and the brake cylinder by the same movement, so as to admit the air and apply the brakes.

11. Q. How many forms of triple valves are there in use, and what are they called?

A. Two; the plain triple and the quick-action triple.

12. Q. How can you tell the plain triple from the quick-action triple?

A. The plain triple has a four-way cock in it, with a handle for operating the cock; the quick-action triple has no such cock in it, but there is a plug cock in the cross-over pipe leading from the train pipe to the triple, when the quick-action triple is used.

13. Q. What are these cocks for in both cases?

A. They are to be used to cut out brakes on one car, without interfering with other brakes on the train, if the brake on that car has become disabled.

14. Q. How does the cock handle stand in the plain triple when the pipe is open for automatic action?

A. It stands in a horizontal position.

15. Q. In what position does the same handle stand when the brakes are cut out by closing the cock?

A. It stands at an inclined position midway between horizontal and vertical.

16. Q. How does the handle in the plug cock in the cross-over pipe, used with the quick action triple, stand for automatic action?

A. It stands with the handle crosswise with the pipe, and groove in plug lengthwise when cock is open.

17. Q. How does the handle and groove stand when the cock is closed and brake cut out of action?

A. It stands with the handle lengthwise of cross-over pipe, and the groove crosswise when closed.

18. Q. How is the train pipe coupled up between the cars?

A. By means of a rubber hose on each end of the train pipe, fitted with a coupling at the loose end.

19. Q. How is the train pipe closed at the rear end of train?

A. By closing the cock in the train pipe at the rear end of last car.

20. Q. How many such train pipe cocks are there to a car, on the air brake train pipe and on the air signal train pipe, and why?

A. Two for each pipe on each car, because either end of any car may sometimes be at the rear end of the train.

21. Q. How many kinds of train pipe cocks are there in use at the ends of the cars?

A. Two.

22. Q. Describe each and give the position of the handle and groove for open and closed in each case.

A. The older form of train pipe cock is a straight plug cock in the train pipe, not far from the hose connection; the handle stands crosswise with the pipe when it is open, and lengthwise with the pipe when closed; it is now found principally on the air signal pipe. The other form of train pipe cock now used on the air brake pipe is an angle cock placed at the end of the train pipe and close to the hose. The handle of the angle cock stands lengthwise with the pipe when open, and crosswise with the pipe when closed. The groove is also a guide to tell whether open or closed.

23. Q. What uses have these train pipe cocks besides to close the pipe at the end of the train?

A. They are used to close the train pipe at both sides of any hose coupling which is to be parted, as when the train is cut in two.

24. Q. Why is it necessary to close the train pipe on both sides of the hose coupling before it is parted?

A. To prevent the escape of air from the train pipe, which would apply the brakes.

25. Q. How must the hose coupling be parted when it is necessary to do so, and why?

A. The air brake must first be released on the train from the locomotive, then the adjacent train pipe cocks must both be closed and the coupling must be parted by hand, to prevent the possibility of injury to the rubber gasket in the coupling.

26. Q. Why must the brakes be fully released before uncoupling the hose between the cars?

A. Because if the brakes are applied upon a detached car they can not be released without bleeding the auxiliary reservoir.

27. Q. In coupling or uncoupling the hose between cars, what must be done if there is ice on the couplings?

A. The ice must first be removed and the couplings thawed out, so as to prevent injury to the rubber gaskets in uncoupling, and to insure tight joints in coupling the hose.

28. Q. What must be done with a hose coupling which is not coupled up, such as the rear hose of a train, or any hose on a car which is standing or running, but not in use?

A. It must be placed in the dummy coupling if provided for in such manner that the flat pad on the dummy will close the opening in the coupling.

29. Q. What pressure should be carried in the train pipe and auxiliary reservoir?

A. The authorized pressure, as per special instructions.

30. Q. Why should the authorized pressure be maintained?

A. Because this pressure is necessary to get the full braking force which each car is capable of using, and, if it be exceeded, there will be danger of sliding the wheels.

31. Q. How much pressure can be obtained in the brake cylinder by the service application of the brakes with seventy pounds in the auxiliary reservoir?

A. About fifty pounds to the square inch, with an 8-inch piston travel.

32. Q. Why can only fifty pounds pressure be obtained under these circumstances?

A. Because the air at seventy pounds pressure in the auxiliary reservoir expands into an additional space when the auxiliary reservoir is opened to the brake cylinder, and when the pressure has become equalized it is thus reduced to fifty pounds.

33. Q. How much must the train pipe pressure be reduced, in order to get fifty pounds pressure in the brake cylinder, in ordinary service?

A. Twenty pounds.

34. Q. Can the brakes be applied so as to get only a portion of this fifty pounds pressure in the brake cylinder, and how?

A. They can be so applied by reducing the train pipe pressure less than twenty pounds.

35. Q. If the train pipe pressure be reduced ten pounds, what will be the pressure in the brake cylinder?

A. About twenty-five pounds.

36. Q. How is this graduated action obtained?

A. By means of the graduating valve in the triple valve.

37. Q. Is it important to keep all the air brake apparatus tight and free from leaks?

A. Yes.

38. Q. Why is this important?

A. In order to get full service from the air brakes, and to prevent the waste of air, and also to prevent the brakes applying automatically by reason of leak in the train pipe.

39. Q. Is it important to know that the train pipe is open throughout the train and closed at the rear end before starting out?

A. Yes, this is very important.

40. Q. Why is this very important?

A. Because if any cock in the train pipe were closed, all the brakes back of the cock which is closed would be prevented from working.

41. Q. How can you ascertain that the train pipe cocks are all open when the train is made up?

A. By testing the brakes; that is, by applying and releasing them, and observing whether they all operate.

42. Q. Do you understand that no excuse will be acceptable for starting out the train without first testing the air brakes?

A. Yes.

43. Q. Why is this rule absolute?

A. Because the safety of passengers and of property depends upon the brakes being properly coupled up and in an operating condition before the train is started.

44. Q. At what other times should the brakes be tested?

A. After each change in the make-up of the train and before starting the train down certain designated grades.

45. Q. From where does the air signal apparatus receive its pressure?

A. From the main air reservoir through the reducing valve.

46. Q. How much air pressure should be carried in the air signal train pipe?

A. The authorized pressure.

47. Q. Is it important that this train pipe and its connections be also kept tight?

A. Yes.

48. Q. After taking up the slack of the brake shoes, how far should the brake piston travel in the cylinders on cars and tenders with a full application of the brake?

A. Not less than six inches, nor more than nine inches.

49. Q. What would happen if the piston traveled less than six inches when brakes are fully applied?

A. A partial application of the brakes might not force the piston beyond the leakage groove in the brake cylinder provided for the escape of small amounts of air.

50. Q. Why should the piston travel not be permitted to exceed nine inches on passenger cars, tenders, or freight cars?

A. Because if it travels farther than this when sent out, a little wear of the brake shoes will cause the piston to travel far enough to rest against the back cylinder head when the brakes are applied, and this cylinder head would then take the pressure instead of its being brought upon the brake shoes.

51. Q. How far should the driver brake piston travel with a full application of the brakes, and why?

A. Not less than two inches nor more than three and one-half inches for the cam type of brake, and from four to six inches for other forms.

52. Q. If the brakes stick upon any car so that the engineman can not release them at any time, how should they be released?

A. By opening the release cock in the auxiliary reservoir and holding it open until air begins to escape from the triple valve, and then closing it again.

53. Q. What is the pressure retaining valve, and what is its use?

A. The pressure retaining valve is a small valve placed at the end of a pipe from the triple valve, through which the exhaust takes place from the brake cylinder. It is used to retard the brake release on heavy grades, and holds the brakes partially applied, so as to allow more time for the engineman to recharge the auxiliary reservoir.

54. Q. What precautions are necessary on every train in regard to hose couplings?

A. Every train must carry at least two extra hose and couplings complete, for use in replacing any hose couplings which may fail or become disabled. These extra hose and couplings to be carried on such part of the train as is required by the rules and regulations.

SPECIAL FOR ENGINEMEN.

55. Q. How should the air pump be started?

A. It should be started slowly, so as to allow the condensation to escape from the steam cylinder and prevent pounding, which is more likely to occur when the air pressure is low.

56. Q. Why should the piston rod on the air pump be kept thoroughly packed?

A. To prevent the waste of air and steam.

57. Q. How should the steam cylinder of the air pump be oiled, and what kind of oil should be used?

A. It should be oiled as little as necessary through a sight-feed lubricator, and cylinder oil should be used.

58. Q. How should the air cylinder of the air pump be oiled; what kind of oil?

A. It should be supplied with valve oil as often as necessary, through a cup provided for that purpose. Also, a well saturated swab should be kept on the piston rod. Lard oil, and other animal or vegetable oils should not be used, as their use causes the brake valve and the triple valves to gum up. The oil must never be introduced through the air inlet ports, as this practice would cause the pump valves to gum up.

59. Q. What regulates the train pipe pressure?

A. The train pipe governor, or feed valve, provided for that purpose.

60. Q. Why should the authorized pressure be carried in train pipe?

A. Because this pressure produces the strongest safe pressure of the brake shoes upon the wheels. A higher train pipe pressure is liable to cause the wheels to slide.

61. Q. What does the feed valve attachment on the brake valve accomplish?

A. When properly adjusted it restricts the train pipe pressure to the authorized amount, with the brake valve handle carried in running position.

62. Q. How often should the brake valve be thoroughly cleaned and oiled?

A. At least once every two months.

63. Q. If the main valve in the brake valve is unseated by dirt or by wear, what may be the result, and what should be done?

A. It may be impossible to get the excess pressure; when the brakes have been applied they may keep applying harder until full on, or when they have been applied they may release. The main valve should be thoroughly cleaned, and if worn it should be faced to a seat.

64. Q. If the piston in the brake valve becomes gummed up or corroded from neglect to clean it, what will be the result?

A. It will be necessary to make a large reduction of pressure through the preliminary exhaust port before the brakes will apply at all, and then the brakes will go on too hard and will have to be released.

65. Q. How and why should the train pipe under the tender always be blown out thoroughly before connecting up to the train?

A. By opening the angle cock at the rear end of the tender and allowing the air from the main reservoir to blow through. This blows out the oil, water, scale, etc., which may accumulate in the pipe, and which would be blown back into the train pipe and triple valves if not removed before coupling to the train.

66. Q. When the locomotive is coupled to the train, why is it necessary to have excess pressure in the main reservoir?

A. So that the brakes will all be released and the train quickly charged when the engineman's valve is placed in the release position.

67. Q. Why should the driver brakes be operated automatically with the train brake?

A. Because it adds greatly to the braking force of the train, and the brakes can be applied alike to all the wheels for ordinary stops, and in an emergency the greatest possible braking force is at once obtained by one movement of the handle.

68. Q. In making a service application of the brakes, how much

reduction of the train pipe pressure from seventy pounds does it require to get the brakes full on?

A. About twenty-five pounds reduction.

69. Q. What should the first reduction be in such an application?

A. Not less than five pounds, so as to insure moving the pistons in the brake cylinders past the leakage grooves.

70. Q. What is the result of making a greater reduction of pressure than twenty-five pounds?

A. A waste of air in the train pipe, without getting any more braking force, and therefore requiring more air to release the brakes.

71. Q. How many applications of the brakes are necessary in making a stop?

A. One or two applications.

72. Q. Why is it dangerous to apply and release the brakes repeatedly in making stops?

A. Because every time the brakes are released the air in the brake cylinders is thrown away, and if it is necessary to apply them again before sufficient time has elapsed to recharge the auxiliary reservoirs the application of the brakes will be weak, and after a few such applications the brakes are almost useless on account of the air having been exhausted from the auxiliary reservoirs.

73. Q. In releasing and recharging the train, how long should the handle of the brake valve be left in the release position?

A. Until the train pipe pressure has risen nearly to authorized pressure.

74. Q. In making service stops with passenger trains, why should you release the brakes just before coming to a full stop?

A. So as to prevent stopping with a lurch; it also requires less time for the full release of the brakes after stopping.

75. Q. In making stops with freight trains, why should the brakes not be released until after the train has come to a full stop?

A. Because long freight trains are apt to be parted by releasing the brakes before rear brakes are fully released.

76. Q. In making service stops, why must the handle of the brake valve not be moved past the position for service applications?

A. So as to prevent unnecessary jerks to the train and the emergency action of the triple valve when not necessary.

77. Q. If you find the train dragging from the failure of the brakes to release, how can you release them?

A. By placing the handle of the brake valve in full release position for a few seconds and returning it to the running position, if the train pipe pressure is not up to the authorized amount; but if maximum pressure is in train pipe, the brakes should be applied with from five to ten pounds

reduction, according to the length of train pipe, and released in the usual manner.

78. Q. When the brakes go on suddenly when not operated by the brake valve, and the gauge pointer falls back, what is the cause, and what should you do?

A. Either a hose has burst, or a conductor's valve has been opened, or the train has parted. In any event, the engine throttle should be closed and the handle of the brake valve should immediately be placed on lap position to prevent escape of air from main reservoir.

79. Q. Are the brakes liable to stick after an emergency application, and why?

A. The brakes are harder to release after an emergency application because they are on with full force and it requires higher pressure than usual in the train pipe to release them again. In this case it is necessary always to have in reserve the excess pressure of the main reservoir to aid in releasing the brakes. With the quick-action triple valve this is especially necessary, because air from the train pipe as well as from the auxiliary reservoir is forced into the brake cylinder when a quick application of the brake is made, thus increasing the pressure in the brake cylinder without the usual reduction of pressure in the auxiliary reservoir, and requiring a correspondingly high pressure in the train pipe afterward to cause the brakes to be released.

80. Q. In using the brakes to steady the train while descending grades, why should the air pump throttle be kept well open?

A. So that the pump may quickly accumulate a full pressure in the main reservoir for use in recharging the train pipe and auxiliary reservoir when the brakes have been released again.

81. Q. In descending a grade, how can you best keep the train under control?

A. First, by commencing the application of the brakes early, so as to prevent too high a speed being reached; secondly, by making an initial reduction that will lightly apply all brakes in the train, and by slowing the train down just before it is necessary to charge the auxiliary reservoir, so as to give time enough to refill same before much speed is again attained.

82. Q. If the train is being drawn by two or more locomotives, upon which locomotives should the brakes be controlled, and what must the engineman of the other locomotive do?

A. The brakes must be controlled by the leading locomotive, and the enginemen of the following locomotives must close the cock in the train pipe just below the brake valves. The latter must always keep the pump running and in order, and main reservoir charged with pressure, with the brake valve in the running position, so that he may quickly operate the brakes if called upon to do so.

83. Q. If the air signal whistle gives only a weak blast, what is the probable cause?

A. Either the reducing valve is out of order so that the pressure is considerably less than forty pounds, or the whistle itself is filled with dirt or not properly adjusted, or the port under the end of signal valve is partly closed by gum or dirt.

84. Q. If the reducing valve for the air signal is allowed to become clogged up with dirt, what will the result probably be?

A. The signal pipe might get the full main reservoir pressure, and the whistle will blow when the brakes are released.

85. Q. If you discover any defect in the air brake or signal apparatus while on the road, what must be done?

A. If it is something that can not be readily remedied at once, it must be reported to the Enginehouse Foreman as soon as the run is completed.

86. Q. What is the result if water be allowed to collect in the main reservoir of the brake apparatus?

A. The room taken up by the water reduces the capacity for holding air, and the brakes are more liable to stick. In cold weather also the water may freeze and prevent the brakes from working properly.

SPECIAL FOR ENGINE REPAIRMEN.

87. Q. How often must the air brake and signal apparatus on locomotives be examined?

A. After each trip.

88. Q. Under what pressure must it be examined?

A. Under full pressure.

89. Q. Should the train pipe pressure exceed the maximum, where would you look for the cause of the trouble?

A. In the devices controlling train pipe pressure.

90. Q. How often must the main reservoir and the drain cup under the tender be drained?

A. After each trip.

91. Q. How often must the triple valves and the cylinders of the driver and tender brakes be cleaned and lubricated?

A. They must be thoroughly cleaned and lubricated once every six months. If the driver brake cylinders are so located that they become hot from the boiler, they may acquire lubrication more frequently.

92. Q. If there are any leaks in the pipe joints or anywhere in the apparatus, what must you do?

A. Repair them before the locomotive goes out.

93. Q. How is the brake shoe slack of the cam driver brake taken up, and what precautions are necessary?

A. By means of the cam screws, and it is necessary to lengthen both alike, so that when the brake is applied the point of contact with the cams will be in a line with the piston rod.

94. Q. How is the brake shoe slack of driver brakes on a locomotive with more than two pairs of driving wheels taken up?

A. By means of a turnbuckle or screw in the connecting rods.

95. Q. How is the slack of the tender brake shoes taken up?

A. By means of the dead truck levers; if they will not take it up enough, it must be taken up in the underneath connection, and then adjusted by the dead lever.

96. Q. How far should the driver brake piston travel in applying the brakes?

A. Not less than two inches, nor more than three and one-half inches with the cam type of brake, and from four to six inches with other forms.

97. Q. What travel of piston should the tender brakes be adjusted for?

A. Not less than two inches, nor more than three and one-half inches with the cam type of brake, and from four to six inches with other eight inches.

SPECIAL FOR TRAINMEN.

98. Q. How should you proceed to test the air brakes before starting out, after a change in the make-up of a train, or before descending certain specially designated grades?

A. After the train has been fully charged with air, the engineman must be required to apply the brakes; when he has done so the brakes must be examined upon each car to see that the air is applied and that the piston travel is not less than six nor more than nine inches. The engineman must then be required to release the brakes; after he has done so, each brake must be examined again to see that all are released. The engineman and conductor must then be notified that the brakes are all right, if they are found so. (In testing passenger brakes, the American Railway Association train air signal whistle code for applying or releasing must be used, one of which signals must be given from the discharge valve on the rear car.)

99. Q. In starting out a passenger train from an inspection point, how many cars must have the brakes in service?

A. Every car in the train.

100. Q. When might you cut out a brake upon a passenger car?

A. Never, unless it gets out of order while on the run, in which

case it must be reported to the inspector at the end of the run, or upon the first opportunity which may give sufficient time to repair it.

101. Q. If a hose bursts upon the run what must be done, if the train is in a safe place?

A. The hose must first be replaced by a good one, and the engineman then signaled to release the brakes. The train must not proceed until the brakes have been reconnected and tested upon the train to see that all are working properly.

102. Q. If the train is not in a safe place when the hose bursts, what must be done?

A. The train pipe cock immediately ahead of the burst hose must be closed and the engineman signaled to release the brakes. The brakes at the rear of the burst hose must then be released by bleeding the auxiliary reservoirs, and the train must then proceed to a safe place to replace the hose and connect up the brakes, after which the brakes must be tested.

103. Q. If the train breaks in two, what must be done?

A. The cock in the train pipe at the rear end of the first section must be closed and the engineman signaled to release the brakes. The two parts of the train must then be coupled, the hose connected and the brakes again released by the engineman. When it is ascertained that the brakes are all released, the train may proceed.

104. Q. Explain how the pressure-retaining valves are thrown into action or thrown out of action, and when this must be done.

A. The pressure-retaining valve is thrown into action by turning the handle of the valve to a horizontal position, and it is thrown out of action again by placing this handle in a vertical position pointing downward. This handle should be placed in a horizontal position at the top of a heavy grade, and it should always be returned to a vertical position at the foot of the grade, as otherwise the brakes will drag on any cars which still have the handle of the pressure-retaining valve in the horizontal position.

105. Q. If the brake of any car is found to be defective on the run, how should you proceed to cut it out?

A. By closing the cock in the cross-over pipe of the quick-action brake, or in the triple valve of the plain automatic brake, and then opening the release cock in the auxiliary reservoir upon that car, leaving it open, if a passenger car, or holding it open until all the air has escaped from it, if a freight car.

106. Q. When it is necessary to cut out a defective brake upon a car, why should it always be cut out at the triple valve and never by the train-pipe cock at the end of the car, even if it is the last car of the train?

A. The train pipe should always be open from the locomotive to the rear end of the last car, so that if the train breaks in two the brakes will be automatically applied before the parts of the train have separated sufficiently to permit damage to be done by their coming together again,

and so that the brakes may be applied with the conductor's valve upon any car.

107. Q. Should the train pipe burst under any car, what must be done?

A. The train must proceed to the nearest switching point, using the brakes upon the cars ahead of the one with the burst pipe, where the car with the burst pipe must be switched to the rear of the train; the hose must then be coupled up to the rear car and the cock at the rear end of the next to the last car opened, and the cock at the forward end of the last car closed, so that if the train should part between the last two cars the brakes will be applied.

108. Q. What is the conductor's valve, and what is its use?

A. It is a valve at the end of a pipe leading from the train-brake pipe upon each passenger car; it is to be opened from the car in any emergency when it is necessary to stop the train quickly, and only then. When used it should be held open until the train is stopped, and then it should be closed.

109. Q. What is the air signal for, and how is it operated?

A. It is to signal the engineman, in place of the old gong signal, and it is operated by pulling directly downward on the cord for one second and releasing immediately, allowing three full seconds to elapse between pulls.

110. Q. If the discharge valve on the air-signal system is out of order or leaking on any car, how can you cut it out?

A. By closing the cock in the branch pipe leading from the train-signal pipe to the discharge valve; to do so the handle of this cock should be placed lengthwise with the pipe.

111. Q. How is the slack taken up so as to secure the proper adjustment of piston travel?

A. By means of the dead-truck lever, and if that is not sufficient, one or more holes must be taken up in the underneath connection and the adjustment then made by the dead-truck lever. Where automatic slack adjusters are applied to any car, such adjuster must be fully released before the slack is taken up elsewhere.

SPECIAL FOR INSPECTORS.

112. Q. Do you understand that no passenger train may be started out with any of the brakes cut out of service?

A. I do.

113. Q. Why is it important that no leaks should exist in the air brake service?

A. Because they would interfere with the proper working of the brakes and might cause serious damage.

114. Q. What must be done with the air brake or air-signal couplings when not united to other couplings, on cars equipped with dummy couplings?

A. They must be secured in the dummy coupling, so that the face of the dummy coupling will cover the opening of the hose coupling so as to prevent dust and dirt from entering the hose.

115. Q. If the air issues from the exhaust port of the quick-action triple valve when the brakes are off, what is the cause?

A. It is probably due to dirt on the rubber seated emergency valve.

116. Q. How often must the cylinder and triple valves be examined, cleaned and lubricated?

A. As often as once every six months on passenger cars and once in twelve months on freight cars. The dates of the last cleaning and lubrication must be marked with white paint on the cylinders.

117. Q. What is the difference between the quick-action passenger and freight triple valve?

A. The passenger triple valves have larger ports and slide valves.

118. Q. How may a passenger triple valve be distinguished?

A. By having one exhaust outlet, or suitable lettering designating the class of service.

119. Q. How may a freight triple valve be distinguished?

A. By its two exhaust outlets, one being plugged.

120. Q. When should the graduating spring of the triple valve be replaced with a new one?

A. When it is worn or rusted out, or not of standard size.

121. Q. To what travel of piston must the brakes be adjusted?

A. Not less than six inches, and this adjustment must be made whenever the piston travel is found to exceed nine inches.

122. Q. How is the slack taken up so as to secure this adjustment?

A. By means of the dead-truck lever, and if that is not sufficient, one or more holes must be taken up in the underneath connection and the adjustment then made by the dead-truck lever. Where automatic slack adjusters are applied to any car, such adjuster must be fully released before the slack is taken up elsewhere.

123. Q. What are the different holes in the outer end of the cylinder levers for, and why must the connections be pinned to the proper hole for each car?

A. These holes are to enable the adjustment of the brake pressure to be made according to the weights of the different cars. The connection must be made to the proper hole in each case, according to the weight of the car, so as to give proper braking power, otherwise the brake will be inefficient, or the wheels may be slid under the cars.

124. Q. How many sizes of high speed brake-reducing valves are there in use, and how will it be known to which size of cylinders they should be connected?

A. There are three sizes, namely, one for 8-inch, one for 10-inch and 12-inch, and a third for 14-inch and 16-inch cylinders, and they can be distinguished by the raised figures cast on their body.

125. Q. To what pressure must the high speed brake-reducing valve be adjusted on passenger equipment cars?

A. The authorized pressure.

CODE OF APPRENTICESHIP RULES.

At the convention of 1898 the following code of rules was adopted as the Recommendation of the Association:

Code of Apprenticeship Rules.

1. A regular apprentice is one who has had no previous shop experience and is not a graduate of a technical institution.

2. No regular apprentice shall be taken into the shop below the age of fifteen or after the age of nineteen years.

3. No apprentice shall be taken into the shop who has not received the elements of a common education, and who does not give evidence of such capacity as to promise the ability to become a competent mechanic.

4. No apprentice shall be taken into the shop without the consent of his parents or lawful guardians, who shall have a thorough understanding of the conditions of such apprenticeship, and who shall execute such documents, including a release of the company from liability for accidents to the said apprentice, as the company may require.

5. The term during which an apprentice shall serve before receiving a certificate of apprenticeship shall not be less than three years, nor more than five years.

6. There shall be a regular apprentice course framed for each shop, which course each apprentice shall go through during his term, the time to be spent on each class of work being defined, and such definition shall be observed as closely as practicable with due regard to the capacities and condition of the individual apprentice.

7. During the term of the apprenticeship a careful and proper record shall be kept of the work and progress of the apprentice, and also of the general behavior and conduct, which record shall be entered on properly authorized blanks or books provided for the purpose not less frequently than once every week during such term.

8. Each apprentice shall be paid for the work done by him upon a scale duly agreed on and provided for in advance.

9. Under no circumstances shall the company assume any liability for the employment of an apprentice after the conclusion of his term.

10. On the conclusion of the term of apprenticeship, each apprentice shall be given a certificate in a proper form, duly signed by the proper officer of the company, which shall set forth the length of time which each apprentice has served and the work on which he has been engaged, as well as some indication of his general behavior during his term.

11. Apprentices who have already served part of a term in other shops, or who have taken part of a course at a recognized technical institution, may be received under such modifications of the foregoing rules as may be deemed proper.

Recommendations Supplementary to the Code of Apprenticeship Rules.

RULE 3. An apprentice should be able to read and write, and have a knowledge of arithmetic. Some companies insist that a candidate shall have reached a point in his studies equivalent to that of the eighth grade of the public schools. This standard, where applicable, will be found satisfactory.

RULE 4. The following is a blank form of release which is recommended as satisfactory:

APPENDIX "C."

(Form for Release of Minors.)

WHEREAS, The A. B. C. Railroad Company has agreed to take into its service .....
a minor, subject to discharge at the pleasure of the company, and has agreed with our consent to pay him the compensation to be earned for his services, and has been authorized to take from him such receipts and acquittances as the said company may require;

AND WHEREAS, The said .....
by reason of such employment, will be subjected to great risk of personal injury from neglect of other employes, agents and officers of the said company, and from defects of machinery, and from other causes;

AND WHEREAS, In the event of injuries to the said.....
....., whether resulting fatally or otherwise, the said.....
or members of his family might make claims for damages against the said company;

NOW, IN ORDER to release the said company from all claims or liability for damages for injuries of any and all kinds, from any cause whatsoever, ...the father, and .....the mother, in their several and individual capacities, and acting as guardian for the said ....., and the said .....himself, in consideration of the employment by the said railroad company of the said .....in the service of the said company, and in consideration of the sum of one dollar now in hand paid by the said company, do hereby release and forever discharge the A. B. C. Railroad Company for all claims for damages, and do also further agree to release the said company from all claims and liability for damages arising out of any injury or injuries to the said.....
.....resulting from the

character of his employment, from the negligence of other employes, or agents or officers of the said company, from defects of machinery or any other cause or causes whatsoever, whilst a minor and whilst in the service of the said company in any capacity whatsoever.

WITNESS our hands and seals this.....day of.....18....

.....[SEAL]

WITNESSES: .....[SEAL]

....[SEAL]

....[SEAL]

....[SEAL]

RULE 5. Four (4) years is recommended as the best standard term. Whenever possible this should be adopted. The limits given in the rule, "not less than three nor more than five years," are made sufficiently wide to cover all special cases. The brightest and most ambitious boy should not be permitted to complete his course in less than three years under any circumstances. A boy who does not complete it in five years had better be something else than a mechanic.

RULE 6. The following courses are recommended for the various shops:

Machine Shop.

TOOL ROOM.— General use of tools, names, etc., work on small planer, drilling machine, shaper and lathes, provide tools; six months to actually serve.

ERECTING SHOP.— Helping on general work — gang No. 1, one month; helping on general work — gang No. 2, one month; helping on general work — gang No. 3, one month.

MACHINE SHOP.— General instructions, milling machine, boring mill, horizontal machine, axle lathe, and helping in general; three months to actually serve.

Boring, driving and truck brasses and quartering machine; two months.

Cylinder boring machine and planer; one month.

Rod: Rod gang, three months; small lathe (alone), two months; large slotter, one month; brass lathe, two months; small planer, one month; large and small planers, two months; driving wheel lathe, one month; large lathe (alone), two months; motion work lathe, one month; general vise work, three months; surface table, three months.

ERECTING SHOP.— General work — gang No. 1, five months; general work — gang No. 2, three months; general work — gang No. 3, four months.

Total number of months' actual service — forty-eight.

Your committee submits this as a basis for an adequate course of training in the machine shop, with the distinct understanding that it is to be qualified so far as the term of service to be spent in the different items, and also in the whole course, by the quality and capacity of the individual boys, under the discretion of whoever has them in charge.

Blacksmith Shop Course.

1. To start the apprentice on a bolt machine for six months. Here he will learn the rudiments of heating iron; also the setting and adjusting of dies, and at the same time by observation will learn the names of the tools and their use in that portion of the shop.

2. The next six months in operating a steam hammer. In this position he has a good opportunity to note how the blacksmiths handle and form iron; at the same time require him to help at the fires in the immediate vicinity of the hammer.

3. The next six months should be as a helper on a small fire, with a man who is quick and handy with light work.

4. The next six months on a light fire without a helper, where he will learn to handle the hand hammer.

5. For the next three months give him a light fire with a helper; the fire should be so located that he will be called upon to assist in taking heats for the larger fires.

6. For the next six months on heavier work that does not require skill.

7. For the next three months put him helping at the tool-dressing fire, and if the shop has two tool-dressing fires, the next three months on the second tool-dressing fire.

8. The next twelve months put him on a heavy fire with as much of a variety of work as can be arranged.

Boiler Shop Course.

1. The first three months heating light rivets.

2. The next three months helping on the heavy sheet-iron work, such as wheel covers, ash pans, etc.

3. Three months holding on rivets for tank work.

4. Three months holding on rivets for boiler work.

5. Six months riveting on patches, chipping and calking on tank work.

6. Six months setting flues.

7. Six months patching and bracing boilers, chipping and calking and general riveting.

8. Six months blacksmithing, to learn how to make and fit braces, to dress necessary tools and assist in fitting up his work.

9. The fourth year to lay out flange and do general boiler work.

RULE 7. It is recommended that some one person be given direct charge of all apprentices and be held responsible for their proper instruction. He can be known as "the Foreman of Apprentices," or he can be designated to perform the duties, without special title, in conjunction with his ordinary work. The following blank page for an Apprentice Record Book is recommended:

APPRENTICE RECORD.

NAME.	WEEKS.																			TOTAL WEEKS WORKED.	AVERAGE CREDIT. CONDUCT AND ABILITY.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14 up to 52 weeks							
John Doe.....	80	50	90	70	50	30	90	80	70	50	30	90	80	70	40	70	80	50	30	.....	63
James Smith.....	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.....	.....
Chas. Jones.....	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	.....	.....

RULE 8. The scale of pay must be governed largely by geographical and individual conditions. It is recommended that the rate of pay be 50 cents for a ten-hour day for the first year, with an increase of 25 cents a day for each year thereafter. For an eight-hour day 40 cents a day at the start and 20 cents a day increase yearly.

RULE 9. The following form of certificate is recommended:

APPENDIX "B."

(Form of Certificate of Apprenticeship.)

A. B. C. RAILROAD COMPANY,

MOTIVE POWER DEPARTMENT.

CERTIFICATE OF APPRENTICESHIP.

.....

has served an apprenticeship as.....

at the shops of this Company at.....

during the period from.....to.....

and has made.....hours time over 10 hours per day.

WORK ON WHICH EMPLOYED.

APPROXIMATE NO. OF MONTHS.	KIND OF WORK.
.....	.....
.....	.....
.....	.....

OFFICERS UNDER WHOM EMPLOYED.

NAME.	TITLE.
.....	.....
.....	.....
.....	.....

GENERAL RECORD OF APPRENTICE.

.....

.....

Supt. Motive Power.

RESOLUTIONS.

Revised and modified at convention, 1903.

At the convention of 1886 the following resolutions prevailed:

Resolved, That this Association deprecates the giving of testimonials or recommendatory letters for publication, and enjoins all to restrict matters of this nature to letters of inquiry. (See page 26, report 1886.)

Resolved, That it is the sense of this convention that in practice it is unnecessary to bead flues in the front end. (See page 152, report 1886.)

At the convention of 1888 the following resolution prevailed:

Resolved, That it is the sense of the Master Mechanics' Association that the pilots of all engines should have steps placed on the front end for the safety and convenience of brakemen while coupling at the front ends. (See page 162, report 1888.)

At the convention of 1893 the following resolution prevailed:

Resolved, That while the Master Mechanics' Association regards the water glass as a convenience and an additional precaution against low water, we do not regard it as an absolute necessity to the safe running of locomotives. (See page 161, report 1893.)

At the convention of 1896 the following resolutions prevailed:

Resolved, That it is the sense of this meeting that the radial stay boiler is as safe as the crown bar boiler, and that the former is easier to keep clean and more economical in repairs. (See page 280, report 1896.)

Resolved, That it is the sense of this Association that the statement of the performance of locomotives should be made on the basis of train load, in lieu of train miles or loaded car miles, as is the prevailing practice at present. (See page 333, report 1896.)

At the convention of 1899 the following resolutions prevailed:

Resolved, That it is the sense of this convention that the time has not arrived when we can abandon instructions to those who use the air brakes, but that the time has arrived when we should perhaps take more care to instruct those who repair the brakes and keep them in order. (See page 71, report 1899.)

Resolved, That it is the sense of the American Railway Master Mechanics' Association that the use of fusible plugs in the crown sheets of locomotive fire boxes is not conducive to the prevention of the overheating of the crown sheet. (See page 153, 1899 report.)

Resolved, That it is the sense of this Association that the ton-mile basis for motive power statistics is the most practical, and encourages economical methods of operating; and that it is desirable that the heads of motive power departments urge its adoption on their managements. (See page 173, report 1899.)

Resolved, That it is the sense of this Association that it is not advisable to use bars in exhaust nozzles. (See page 277, report 1899.)

At the convention of 1901 the following resolutions prevailed:

Resolved, That it is the sense of this Association that a strict comparison of motive power statistics, one road with another, will not secure the best results, but that such comparisons should be made with the records of the same division for preceding periods of time. (See page 79, report 1901.) (See modification, page 70, 1902 report.)

Resolved, That it is the sense of this Association that the ton-mileage of the locomotive is a just credit to the motive power department for statistical purposes. (See page 83, report 1901.) (See modification, page 77, 1902 report.)

Resolved, That it is the sense of this Association that it is necessary that the side rods should be on engines traveling from the works to the railroad they are built for. (See page 99, report 1901.)

At the convention of 1902 the following resolutions prevailed:

"*Resolved,* That it is the sense of this Association that conclusions based on a comparison of the statistics of one railroad with another may easily prove incorrect, should be given less weight than they usually are, are just only when the accompanying conditions are fairly well known and their influence can be determined with some degree of accuracy; that a comparison of the statistics of a division or a system with those of the same territory for a previous corresponding period very largely eliminates these uncertainties and makes conclusions based on such a comparison much more reliable."

"*Resolved,* That it is the sense of this Association that the ton-mileage of the locomotive and caboose is a just credit to the motive power department for statistical purposes."

"*Resolved,* That the ton-mile is the best practical basis now available for motive power and operating statistics by which to judge the efficiency of locomotive and train service.

"*Resolved,* That actual tonnage should be used in computing ton-mile statistics for comparison with those of other roads, but for comparison with the previous records of the same system or division the use of adjusted tonnage is advisable.

"*Resolved,* That the statistics of passenger, freight, work train and switching services should be on the ton-mile basis, each service in a separate group, and passenger and freight service to be each further grouped under Through and Local.

"*Resolved,* That the statistics of branch lines and main lines should be kept separately.

"*Resolved,* That the credit of ton-mileage for locomotives in switching service should be proportional to their tractive power.

"*Resolved,* That the ton-mileage of trains using more than one locomotive should be divided among the locomotives attached to these trains in proportion to their tractive power and for the distance over which the helping locomotives are used.

"*Resolved,* That the tonnage of the locomotive should be its weight in working order, plus the light weight of the tender and half its capacity of coal and water."

Obituary.

R. H. GILMOUR.

At Schenectady, New York, on October 26, 1904, Mr. R. H. Gilmour, perintendent of Brooks Works of the American Locomotive Company, ed suddenly from heart trouble.

With headquarters at Dunkirk, N. Y., he was in Schenectady attending meeting of Superintendents of the several branches of the American ocomotive Company when death claimed him.

Mr. Gilmour was born in Toronto, Canada, and was in the fifty-first ear of his age. His parents were Scotch and from them he no doubt nherited the characteristics forming the salient features of his personality and qualifying him for his success in the chosen path of life. His father was a gentleman of wide experience and exceptional ability in railroad mechanics and it was quite natural for the son to distinguish himself on similar lines.

Receiving an education in Toronto schools, he afterward served an apprenticeship in the Grand Trunk Railway shops in that city, learning the trade of machinist. Following that time, he spent two or three years in different shops where knowledge and experience were to be acquired, a portion of the time being devoted to active railroad engineering.

In 1878 he entered the Government Engineering Department at Ottawa and Toronto, continuing in that service for two years. During the five years following he was connected with the Northern Railway of Canada, for a period, later in charge of the mechanical operation of extensive saw-mills at Trenton, Canada, resigning that position to take charge of the water service of the entire line of the Grand Trunk Railway.

Desiring to see the Western country he accepted a position with the Canadian Pacific Railroad, with headquarters at Broadview, Alberta. From there he removed to Portage la Prairie and was appointed Master Mechanic of the Manitoba & Northwestern Railroad. At the expiration of two years he resigned to take position as general foreman of the Chicago & Atlantic Railroad, at Huntington, Indiana, resigning that position a year later to accept a similar one on the Northern Pacific Railroad, at Brainerd, Minn. While in that position he was appointed master mechanic of the Manitoba Division, with headquarters at Winnipeg.

In 1894 he left the Northern Pacific, after six years' service and

accepted the position of superintendent of the Watrous Iron Works, Brantford, Canada. In seven years with this company he brought the mechanical department to a state of perfection second to none and made of it a monument to his ability and efficiency. As a result of his achievements, the Canada Foundry Company, Toronto, engaged him as superintendent, where he also evidenced his superior mechanical ability.

In January, 1903, he was tendered and accepted the position held at the time of his death. In the discharge of his duties he attained the same success as had been won in the past.

In his official capacity, Mr. Gilmour brought all his energies into service, which, combined with wide experience and natural executive ability, gained him a high standing in the ranks. Conservative in his ideas, cautious and prudent in his conclusions and determined in his convictions, he earned and retained the respect and esteem of all with whom he came in contact.

In private life he was very unassuming and rather reserved, but was always a genial and sociable acquaintance. Liberal and broadminded, he was of a generous disposition and in matters harmonious with his inclinations he was generous to a fault.

Besides the Railway Master Mechanics' Association he was a member of I. O. O. F. and of the Foresters.

Mr. Gilmour was married in 1876 and leaves a wife and four children, a son and three daughters, two children having died some years ago.

JAMES MCNAUGHTON.

CHRISTOPHER FALLON THOMAS.

Was born in Media, Delaware County, Pennsylvania, in 1855. He entered the Pennsylvania Railroad shops at Renova, Pennsylvania, as an apprentice in 1875. After serving his apprenticeship he accepted a position with the Mobile & Montgomery Railroad, and in 1880 entered the service of the Louisville & Nashville Railroad as general foreman at Nashville, Tennessee. In 1883 he went with the Chesapeake & Ohio Railway as general foreman of shops at Hinton, West Virginia, and in 1884 was promoted to the position of master mechanic of the Richmond Division. He left the service of the Chesapeake & Ohio to accept a position on the Georgia Division of the East Tennessee, Virginia & Georgia Railroad, at Atlanta, Georgia. In May, 1890, he entered the service of the Central Railroad of Georgia, as master mechanic, at Macon, Georgia, which position he resigned in 1890 to enter the service of the Richmond & Danville Railroad, at Alexandria, as master mechanic. In 1902 he was transferred to the Southern Railway shops, at Columbia, South Carolina,

and in September of the same year entered the service of the American Locomotive Company as general inspector, at their Richmond works. Pulmonary troubles having developed, he resigned January 1, 1904, and accepted an offer made him by the Baldwin Locomotive Works for special work in California and New Mexico, in which he was engaged at the time of his death. Mr. Thomas was a member of the American Railway Master Mechanics' Association and the Master Car Builders' Association and took an active part in these societies, having done efficient work on a number of committees. He possessed an extraordinary knowledge of mechanical matters, and being a great student, kept fully abreast of the times, especially as to economical shop practice. He designed many improvements and invented many of the "shop kinks" now in common use. His sturdy honesty, unselfish character anl loyal friendship endeared him to those who knew him. He died in Albuquerque, New Mexico, October 25, 1904, and was buried at Downingtown, Pennsylvania.

W. H. THOMAS.

DORRELL SINGLETON COOPER.

Master Mechanic of the Richmond, Fredericksburg & Potomac Railroad and Washington Southern Railway, died at Richmond, Virginia, April 22, 1904, after a brief illness.

He was born in Richmond, Virginia, near the corner of Broad and Twenty-fifth streets, August, 1845.

At the age of sixteen years he entered the shops of Etinger & Edmonds as a machinist apprentice, continuing there only a short time. He resumed his apprenticeship with the R. & P. R. R. in Manchester, Virginia, under Mr. William Ransome, master mechanic, serving nearly four years.

About the latter part of 1864 he enlisted in the Confederate States Army in Mahone's brigade. He was wounded shortly after enlisting, and from then on saw very little active service.

He assisted in placing the armor on the Confederate ram Merrimac, which consisted of strap rail taken from the R. & Y. R. R. R., which ran from Richmond to West Point. After the close of the war he assisted in repairing and putting in shape the rolling stock of the above mentioned railroad. He acted as foreman and engineer on this road until the latter part of 1869, when he secured a position with the R. F. & P. Connection R. R. as engineman, holding this position about eighteen years, after which he acted as engineman on the R. F. & P. between Richmond and Quantico. He was made road foreman of engines, and finally on the death of Master Mechanic Bryant, was made master mechanic.

He married Miss McDonough, of Richmond, in 1871. Eleven children

were the result of this union, five boys and six girls. Four daughters, three of whom are married, and his wife, survive him.

Mr. Cooper was very genial in his disposition, and was beloved by all who knew him. He was always willing to extend a helping hand to those who were in trouble. W. F. KAPP.

G. W. HEPBURN.

Mr. G. W. Hepburn was born in Bloomington, Maryland, in 1869, and died at Hinton, West Virginia, April 28, 1904. He entered the Baltimore & Ohio Railroad shops at Piedmont, West Virginia, in 1885, where he served his apprenticeship. After serving his apprenticeship, he was transferred to the Baltimore & Ohio shops at Glenwood, Pittsburg, Pennsylvania. He left that place to enter the service of the Chesapeake & Ohio Railway as machinist, at Hinton, West Virginia. He was promoted to night roundhouse foreman in 1890, and was, during the same year, promoted to general foreman at Hinton. In 1893 he was promoted to assistant master mechanic at Hinton, West Virginia. In 1900 he was promoted to assistant master mechanic of the Cincinnati Division, with headquarters at Covington, Kentucky, and in July, 1902, was promoted to master mechanic of the Kentucky Division, with headquarters at Covington, Kentucky. In February, 1903, he resigned and took service with the Baltimore & Ohio Southwestern Railway, at Washington, Indiana. He became a member of the American Railway Master Mechanics' Association in 1897. J. F. WALSH.

JOHN RUGGLES SLACK.

John Ruggles Slack died in the Presbyterian Hospital, New York City, August 1, 1904.

Mr. Slack was born June 24, 1863, educated at Columbia College, 1884, and at Stevens Institute of Technology, 1886. He entered railway service in 1886 as apprentice in shops of the New York Central & Hudson River Railroad, since which he has been, consecutively, to February, 1890, draftsman for the West Shore, at Frankfort, New York; February, 1890, to June, 1898, inspector of locomotives and mechanical engineer of the New York Central & Hudson River Railroad; June, 1898, to July, 1899, mechanical engineer of the Central Railroad Company, of New Jersey; July, 1899, to

January, 1902, assistant superintendent motive power of the Delaware & Hudson Company, and from January, 1902, to March 9, 1904, superintendent motive power, same company. On March 9 Mr. Slack was appointed assistant to general superintendent of the Delaware & Hudson Company. He was a member of both the Master Car Builders' and Master Mechanics' Associations, having joined the former in 1899 and the latter in 1900.

Mr. Slack was a man of sterling qualities, businesslike, courteous and agreeable to all. His friends were everywhere; than this, what higher tribute to his memory could be paid? Devotion to duty and application to the business in hand were marked characteristics of Mr. Slack. They constituted the keystone of the arch upon which he built his successful and honorable career. His early demise will be deeply regretted by a host of friends. J. H. MANNING.

T. M. CONLON.

Mr. Conlon was born at Charleston, South Carolina, May 23, 1862, and entered the railway service in 1879 as machinist apprentice in the shops of the South Carolina Railroad, at Charleston, serving four years, after working a short time as machinist, was promoted to a locomotive engineer in the fall of 1883. As an engineer he was successful, and was running a passenger train when promoted to air-brake inspector for the instruction of engineers, firemen and trainmen. He returned to his former position as engineer after this work was completed, and after this he was appointed road foreman of engines, which position he held for about one year, when he was appointed general foreman of the shops at Charleston. Shortly after assuming this position he was appointed master mechanic of the Charleston Division of the Southern Railway, which position he held for nearly four years, when he resigned to assume his former position, that of locomotive engineer, and while serving in that capacity, met his death in an accident, which occurred April 24, 1905.

Mr. Conlon became a member of the American Railway Master Mechanics' Association in June, 1901. A. STEWART.

JAMES M. BOON.

James M. Boon was born in Philadelphia, January 4, 1833, and died at his residence in Chicago, July 31, 1904. Mr. Boon served an apprenticeship of five years at the Locomotive Works of Matthias W. Baldwin and was employed there as a machinist, 1854 to 1855. In 1857 he was with the Western Atlantic Railroad, Georgia; 1858-1859, Matanzas Railroad, Cuba; 1859-1860, Pittsburg, Fort Wayne & Chicago Railway. From 1860 to 1866 he was foreman of the Fort Wayne shop; October, 1866, to 1869 he was master mechanic of the Union Pacific, at Wyandotte, Kansas; 1869-1881, master mechanic of Western Division of P. F. W. & C. Ry.; 1881-1884, assistant superintendent motive power Chicago & North-Western Railway; 1884-1897, assistant superintendent motive power New York, West Shore & Buffalo Railway. In June, 1897, he retired from active service. Mr. Boon was one of the most prominent of the early members of the Master Mechanics' Association, having joined it in 1869, and for many years he was an active worker on committees and at the conventions of this Association. It is probable that none of the older members was more generally admired for his sterling integrity, his high estimate of character and his general good nature. Mr. Boon was a skilful mechanic and a successful motive-power officer. He belonged to that order of old-time master mechanics, which was well named, as they were masters of their profession. His enterprising and progressive spirit was rather unusual and it kept him well up with the times, and led him to encourage improvements and new methods.

During his later years, Mr. Boon was afflicted so that he was confined to his bed for three years. During these long, weary days of suffering, he never lost his interest in his mechanical work, and one of his greatest pleasures was to hear of the progress and advancement of the mechanical interests of the country. Mr. Boon is survived by a son and daughter.

WILLIAM FORSYTH.

INDEX.

A

Address of President, 31-35.
Air brake and train air signal instructions, 365-388.
American Loco. Co. design of superheater arrangement, 101-104.
Annual dues, assessment of, 51.
Apprenticeship, discussion on the subject of, 185-203.
Apprenticeship rules, code of, 388-393.
Associate member, A. W. Bodler, proposed, 313.
Associate member, J. L. Replogle, proposed, 52-53.
Auditing committee, election of, 51-52.
Auditing committee, report of, 132.
Axles and forgings specifications, report of committee on, 134-138.
Axles, standard, 358.

B

Ballot, letter, circular relating to, 319-323; result of, 324.
Basford, G. M., individual paper on "The Technical Education of Railroad Employes," 174-184.
Beading of flues, resolution regarding, 394.
Benjamin, J. D., remarks of, 312-313.
Bodler, A. W., proposed for associate member, 313.
Boiler and fire-box steel, specifications for, standard, 331-334.
Bolts, flexible stay, report of committee on, 203.
Bolt heads, standard, 327.
Briggs' standard pipe threads, 357.
By-laws and constitution, 7-14.
By-pass valves, discussion on, 299-305.

C

Cast-iron wheel centers, tire shrinkage, discussion on, 143-154.
Cast-iron wheels, specifications, tests and guarantee for, 362-364.
Circular relating to letter ballot, 319-324.
Code of apprenticeship rules, 388-393.
Committee report on:
    Correspondence and resolutions, 312.
    Flexible stay bolts, 203.

Locomotive front ends, 274-283.
Locomotive terminal facilities; heating and ventilating roundhouses, 155-164.
Locomotive tests of the P. R. R. at St. Louis Exposition, 73.
Shop lay-outs, 217-264.
Specifications for axles and forgings, 134-138.
Subjects, 310-311.
The proper loading of locomotives, 54-64.
Time service of locomotives, 210-215.
Water softening, 204-206.
Committee on supervision of M. M. dictionary, appointment of, 133-134.
Committee, auditing, election of, 51-52.
Committees, list of, 3-6.
Constitution, amendment of, 313-314.
Constitution and by-laws, 7-14.
Correspondence and resolutions, appointment of committee on, 52.
Correspondence, report on, 312.
Cory, C. H., elected life member, 133.

D

Decimal gauge, standard, 356.
Designs of superheaters, 101-104.
Dictionary, M. M., approval of *Railroad Gazette* plan to print, 133; committee on, 133-134.
Dimensions of water space around fire boxes, topical discussion, 74-84.
Discussion of individual paper on superheaters, 121-129.
Discussion of individual paper on "The Technical Education of Railroad Employes," 184-203.
Discussion of reports on:
Flexible stay bolts, 203.
Locomotive tests of Penna. R. R. at St. Louis Exposition, 73-74.
Locomotive terminal facilities; heating and ventilating roundhouses, 164-174.
Locomotive front ends, 284-286.
Shop lay-outs, 264-273.
Shrinkage allowance for tires, 143-154.
Specifications for locomotive forgings and axles, 138-139.
The proper loading of locomotives, 64-72.
Time service of locomotives, 215-216.
Water softening for locomotive use, 207-210.
Discussion of topical subjects:
Dimensions of water spaces around fire boxes, 74-84.
High-speed steel, 286-287.
Mechanical stokers, 288-299.

Relief and by-pass valves, 299-305.
Self-cleaning front ends, 305-309.
Driving wheel centers, standard, 330.
Dues collected, details of, 43-50.
Dues, annual, assessment of, 51.

E

Economical loading of locomotives, report on, 54-67.
Education (technical) of employes, individual paper on, 174-184.
Election of auditing committee, 51-52.
Election of officers, 314-317.
Electrical purification of water for locomotive use, 209-210.
Employes (railroad), the technical education of, paper on, 174-184.
Executive members, modification of constitution to provide for, 313.
Exhaust nozzles, use of bars in, resolution regarding, 395.
Expenses and receipts, 39.

F

Factors affecting the economical loading of locomotives, report on, 54-67.
Firemen, mechanical, topical discussion on, 288-299.
Fire-box steel, specifications for, standard, 331-334.
Flexible stay bolts, report of committee on, 203.
Forgings, and axles, specifications for, report of committee on, 134-138.
Friday's session, 204.
Front ends, locomotive, report of committee on, 274-283.
Front ends, self-cleaning, topical discussion on, 305-309.
Fry, Lawford H., topical discussion: dimensions of water spaces around fire boxes, 74-84.
Fry, Lawford H., proposed as associate member, 132.
Fusible plugs, use of, resolution regarding, 394.

G

Guarantee for cast-iron wheels, recommendation, 363-364.

H

Heating and ventilating roundhouses, report on, 155-164.
High-speed steel, topical discussion on, 286-287.
History of development of use of superheated steam on locomotives, 84-88.
Honorary member, G. W. Rhodes elected, 52-53.
Howe, H. B., remarks of, 129-131.

I

Individual papers:
The technical education of railroad employes, 174-184; discussion on, 184-203.
The use of superheated steam on locomotives, 84-120; discussion of, 121-129.
Instruction of air brake men, resolution regarding, 394.

J

Journal box, bearing and pedestal, standard, 358.

L

Letter ballot, circular relating to, 319-323; result of, 324.
Life members, G. W. Rhodes elected, 54; C. H. Cory elected, 133.
Limit gauges for round iron, standard, 329.
Loading of locomotives, factors affecting the economical, 54-64.
Locomotive terminal facilities; heating and ventilating roundhouses, report on, 155-164.
Locomotives, time of service of, report of committee on, 210-215.
Locomotive front ends, report of committee on, 274-283.
Locomotive performance on train-load basis, resolution regarding, 394.

M

Master Mechanics' dictionary, approval of *Railroad Gazette* plan for a, 133.
Mechanical stokers, topical discussion on, 288-299.
Members, list of, 15-30.
Membership, active, 37.
Associate, 38.
Honorary, 38.
Representative, 40-41.
Methods of heating and ventilating roundhouses, report on, 155-164.
Method of conducting locomotive efficiency tests, standard, 334-350.
Mileage allowance for keeping cost of repairs of switching engines, 362.
Mileage allowance for keeping cost of repairs of local freight engines, 362.
Mileage allowance for keeping cost of repairs of empty engines at terminals, 362.

N

Nuts, size of standard, 327.

O

Obituaries, appointment of committees on, 52.
Obituaries, R. H. Gilmour, 397-398; C. F. Thomas, 398-399; D. S. Cooper, 399-400; G. W. Hepburn, 400; J. R. Slacks, 400-401; T. M. Conlon, 401; J. M. Boon, 402.
Officers, election of, 314-317.
Officers for 1905-6, 2.

P

Pielock system of superheater arrangement, 101-104.
Pipe threads, Briggs' standard, 357.
Plate 1. Standard axles and section of tire.
Plates 2 to 13. Standard journal boxes, bearing and wedges.
Plate 14. Standard pedestal.
President's address, 31-35.
Purification of water for locomotive use, report of committee on, 204-206.

R

Radial stay boilers, resolution regarding, 394.
Railroad Gazette, approval of plan to print M. M. dictionary, 133.
Railway shops, report of committee on, 217-264.
Receipts and expenses, 39.
Recommendations of the Association, 362-393.
- Air brake and train air signal instructions, recommendation, 365-388.
- Code of apprenticeship rules, recommendation, 388-393.
- Guarantee for cast-iron wheels, recommendation, 363-364.
- Mileage allowance for keeping cost of repairs of switching engines, 362.
- Mileage allowance for keeping cost of repairs of local freight engines, 362.
- Mileage allowance for keeping cost of repairs of empty engines at terminals, 362.
- Specifications for cast-iron wheels, recommendation, 362-363.
- Test for cast-iron wheels, recommendation, 363.

Relief and by-pass valves for locomotives, topical discussion, 299-305.
Replogle, J. L., proposed for associate member, 52-53.
Report of Secretary, 37-50.
Report of Treasurer, 51.
Reports of committees on:
- Auditing, 132.
- Correspondence and resolutions, 312.
- Flexible stay bolts, 203.
- Locomotive front ends, 274-284.
- Locomotive tests of Penna. R. R. at St. Louis, 73.

Locomotive driving and truck axles and forgings, 134-138.
Locomotive terminal facilities; heating and ventilating roundhouses, 155-164.
Shop lay-outs, 217-264.
Shrinkage allowance for tires, 140-143.
Subjects, 310-311.
The proper loading of locomotives, 54-67.
Time service of locomotives, 210-215.
Water softening for locomotives, 204-206.
Resolutions and correspondence, appointment of committee on, 52.
Resolutions of the Association, 394-396.
Bars in exhaust nozzles, 395.
Beading of flues in front end unnecessary, 394.
Instruction of air brake men, 394.
Locomotive performance on train-load basis, 394.
Radial stay boilers, 394.
Recommendatory letters, 394.
Steps on pilots, 394.
Ton-mile basis for motive power statistics, 395-396.
Use of fusible plugs, 394.
Water glasses, 394.
Resolutions regarding Mr. R. H. Soule, 132.
Resolutions, report of committee on, 312.
Result of letter ballot, 324.
Rhodes, G. W., elected honorary member, 53-54.
Roundhouses, heating and ventilating, report of committee on, 155-164.

S

Sauvage, Edw., privileges of floor extended to, 51.
Scholarships, 40.
Schmidt design of superheater, 101-104.
Schools for instruction of apprentices, discussion on, 184-203.
Screw threads, standard, 325-326.
Secretary's report, 37-50.
Section of tires, standard, 330-331.
Service of locomotives, time, report of committee on, 210-215.
Sheet metal gauge, standard, 329.
Shrinkage allowance for tires, report of committee on, 140-143.
Shop lay-outs, report of committee on, 217-264: general considerations, 223; erecting shop, 225; longitudinal and transverse shops compared, 231-234; machine shop, 234-238; boiler and smith shop, 238-242; power plant, 242-249; relative arrangement and track connections, 249-258; scrap bins, 251; turntables, 251-252; modern plans described, 252-258; conclusions, 258-264.

Sizes of tires, standard, 330.
Specifications for locomotive axles and forgings, report of committee on, 134-138.
Specifications for locomotive boiler tubes (iron), standard, 350-352.
Specifications for cold-drawn steel boiler tubes, standard, 352-356.
Specifications for locomotive driving and truck axles, standard, 358-359.
Specifications for locomotive forgings, standard, 359-360.
Specifications for steel blooms and billets, standard, 360-361.
Specifications for boiler and fire-box steel, standard, 331-334.
Specifications for cast-iron wheels, recommendation, 362-363.
Square bolt heads, size of, standard, 328.
Standards of the Association:
Axles, 358. (See plate 1.)
Boiler and fire-box steel, specifications for, 331-334.
Bolt heads, 327.
Decimal gauge, 356.
Driving wheel centers, 330.
Journal box, bearing and pedestal, 358. (See Plates 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14.)
Limit gauges for round iron, 329.
Method of conducting efficiency tests of locomotives, 334-350.
Nuts, 327.
Pipe threads, Briggs' standard, 357.
Pipe unions, 358.
Screw threads, 325-326.
Sheet metal gauge, 329.
Specifications for iron locomotive boiler tubes, 350-352.
Specifications for cold-drawn steel locomotive boiler tubes, 352-356.
Square bolt heads, size of, 328.
Specifications for locomotive driving and engine truck axles, 358-359.
Specifications for steel blooms and billets for forgings, 360-361.
Specifications for forgings, 359-360.
Tires, sizes of, 330; section of, 330-331.
Stay bolts, flexible, report of committee on, 203.
Steam, superheated, use of, paper on, 84-120.
Steel wheel centers, tire shrinkage on, discussion on, 143-154.
Steel, high-speed, topical discussion on, 286-287.
Steps on pilots, resolution regarding, 394.
Stokers, mechanical, topical discussion, 288-299.
Subscribers to fund on locomotive front end tests, 274-275.
Subjects, report of committee on, 310-311.
Superheated steam on locomotives, use of, individual paper on, 84-120; history, 84-88; theory, 88-100; designs, 101-104; results obtained, 104-115; general conclusions, 115-120.
Systems of treatment for water purification, report on, 204-206.

T

Technical education of employes, individual paper on, 174-184; the problem, 174-175; the motive power official, 175-176; what growth has done, 176-177; recruiting, 177-178; mistakes, 178-179; the plan, 179-182; what has been done, 182-183; conclusions, 184.
Terminal, locomotive, facilities, report of committee on, 155-164.
Tests for cast-iron wheels, recommendation, 363.
Tests of different designs of superheaters, 104-115.
Theoretical considerations involved in the use of superheated steam on locomotives, 88-100.
Thursday's session, 131-203.
Time service of locomotives, report of committee on, 210-215.
Tire, sizes and section of, 330-331. (See Plate 1.)
Tires, shrinkage allowance for, report of committee on, 140-143.
Ton-mile statistics, resolutions regarding, 395-396.
Topical discussions:
Dimensions of water space around fire boxes, by L. H. Fry, 74-84.
High-speed steel, 286-287.
Mechanical stokers, 288-299.
Relief and by-pass valves for locomotives, 299-305.
Self-cleaning front ends, 305-309.
Traveling Engineers' Association, privileges of floor extended to representative of, 52.
Treasurer's report, 51.
Treatment of water for locomotive use, report on, 204-206.

V

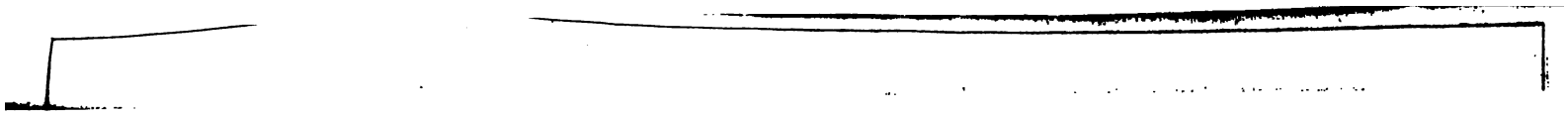
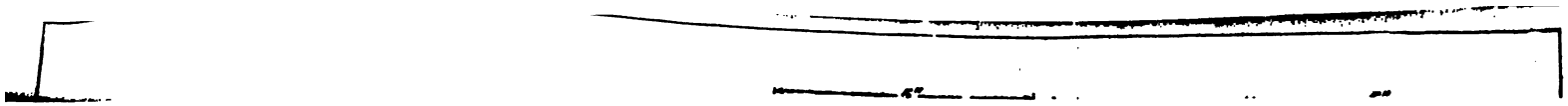
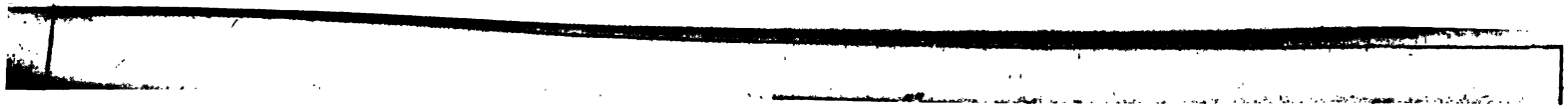
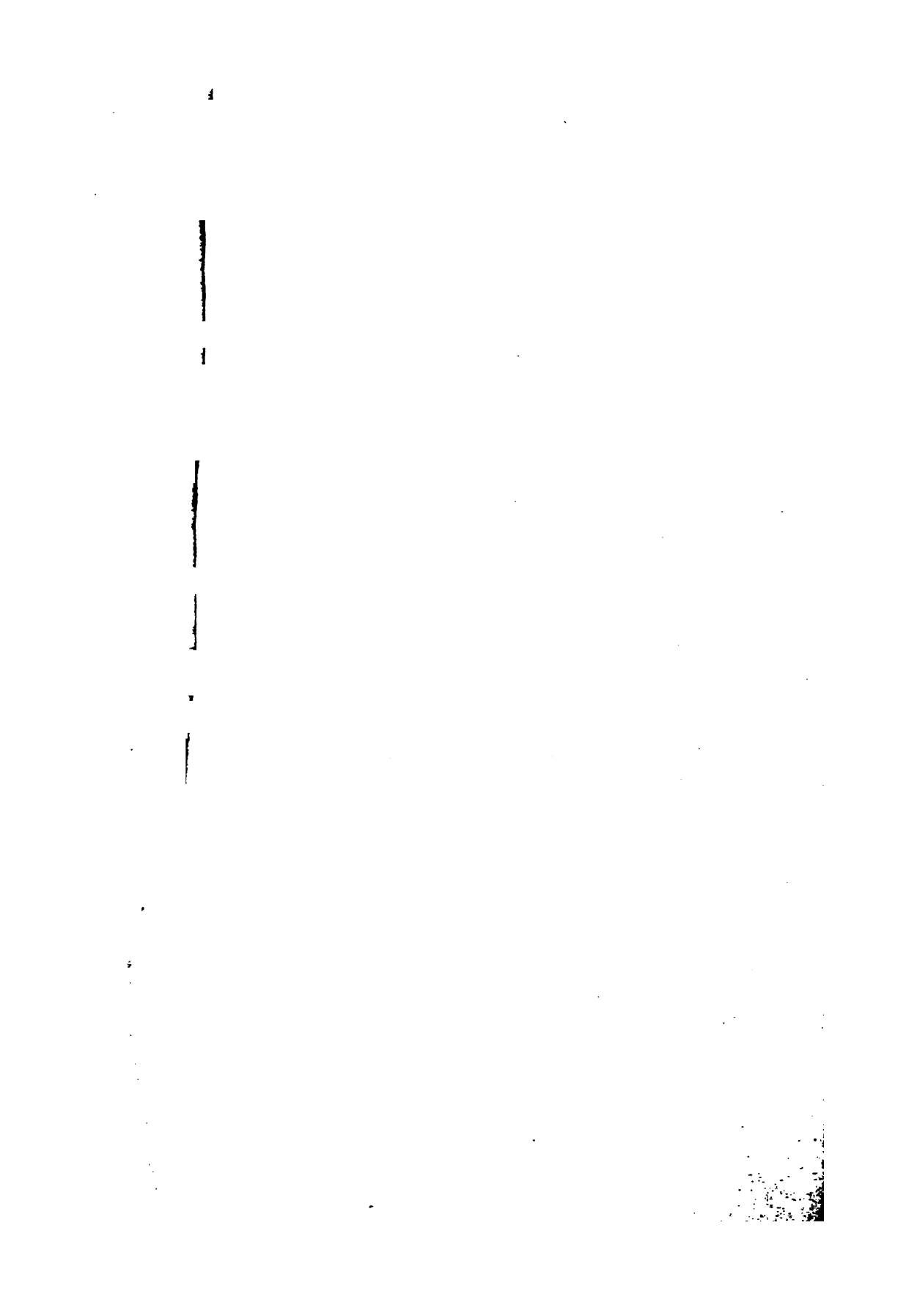
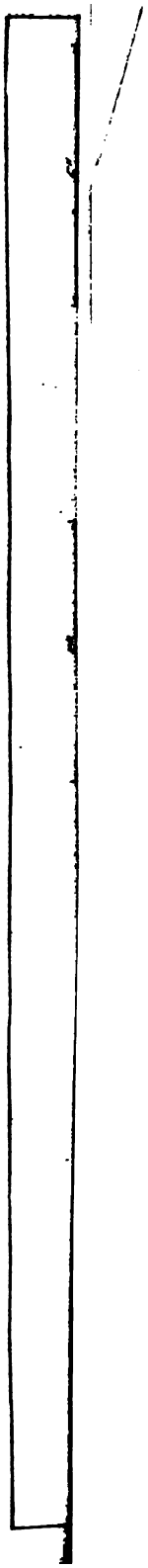
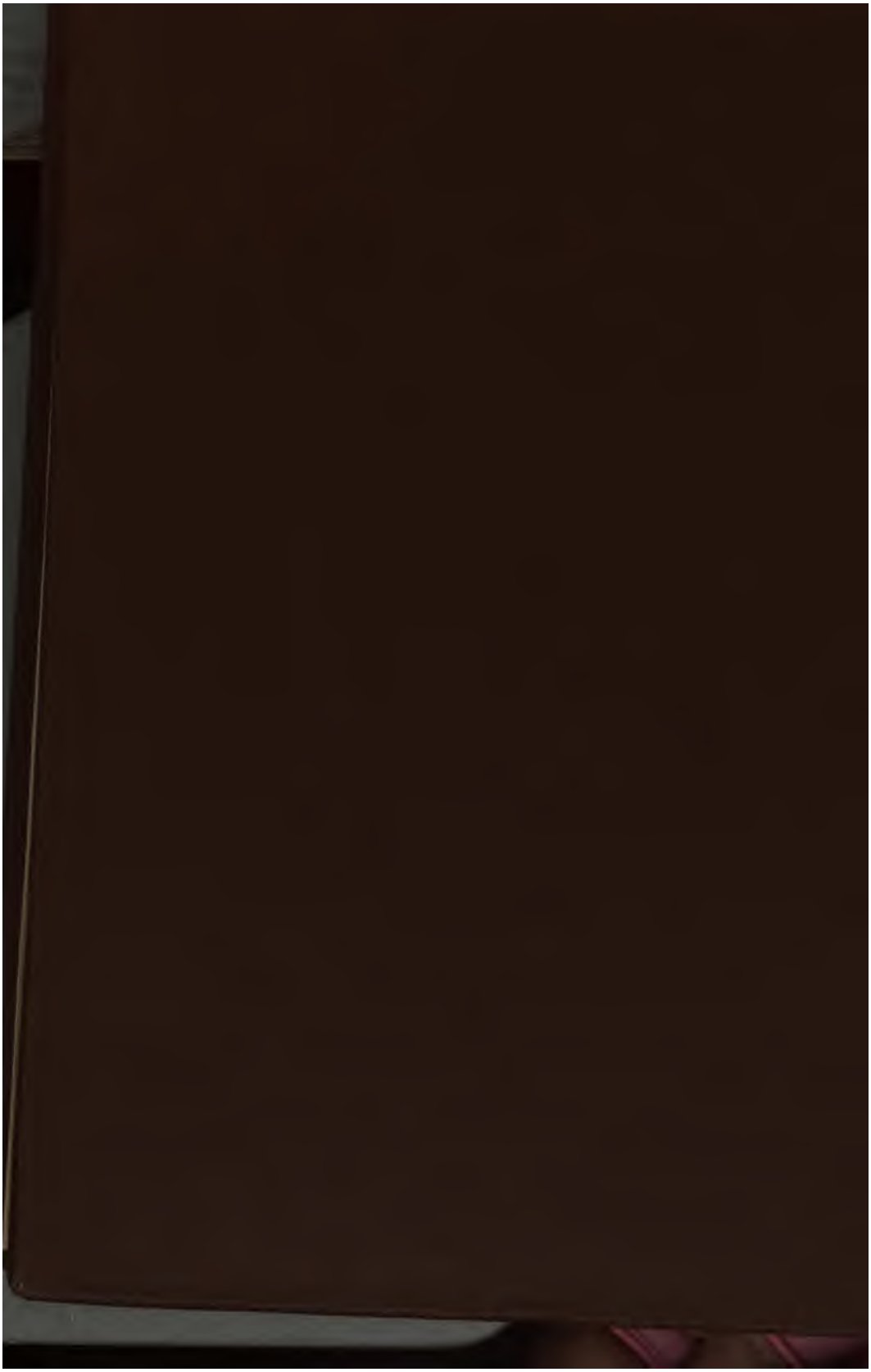
Valves, relief and by-pass, topical discussion on, 299-305.
Vaughan, H. H., individual paper on use of superheated steam, 84-120.
Ventilating and heating roundhouses, report of committee on, 155-164.

W

Water glasses, resolution regarding, 394.
Water softening, report of committee on, 204-206.
Water spaces around fire boxes, topical discussion, 74-84.
Wednesday's session, 31-131.
Wheel centers, steel and cast iron, shrinkage allowance, discussion on, 143-154.
Wheels, cast-iron, specifications, tests and guarantee for, 362-364.

PAST PRESIDENTS.

H. M. BRITTON,	1868 to 1876.	Deceased.
N. E. CHAPMAN,	1876 " 1880.	Deceased.
J. N. LAUDER,	1880 " 1882.	Deceased.
REUBEN WELLS,	1882 " 1884.	
JOHN H. FLYNN,	1884 " 1885.	Deceased.
J. DAVIS BARNETT,	1884 " 1885.	Acting President.
J. DAVIS BARNETT,	1885 " 1886.	
WILLIAM WOODCOCK,	1886 " 1887.	Deceased.
JACOB JOHANN,	1886 " 1887.	Acting President.
J. H. SETCHEL,	1887 " 1889.	
R. H. BRIGGS,	1889 " 1890.	
JOHN MACKENZIE,	1890 " 1892.	
JOHN HICKEY,	1892 " 1894.	
W. GARSTANG,	1894 " 1895.	
R. C. BLACKALL,	1895 " 1896.	Deceased.
R. H. SOULE,	1896 " 1897.	
PULASKI LEEDS,	1897 " 1898.	Deceased.
ROBERT QUAYLE,	1898 " 1899.	
J. H. McCONNELL,	1899 " 1900.	
W. S. MORRIS,	1900 " 1901.	
A. M. WAITT,	1901 " 1902.	
G. W. WEST,	1902 " 1903.	
W. H. LEWIS,	1903 " 1904.	
P. H. PECK,	1904 " 1905.	

65000 LBS

WIDTH OF
WHERE LID
BE 7/8 INCH
ANCE WITH
180). INSTEAD
AS SHOWN I
SEE PL
PROCE